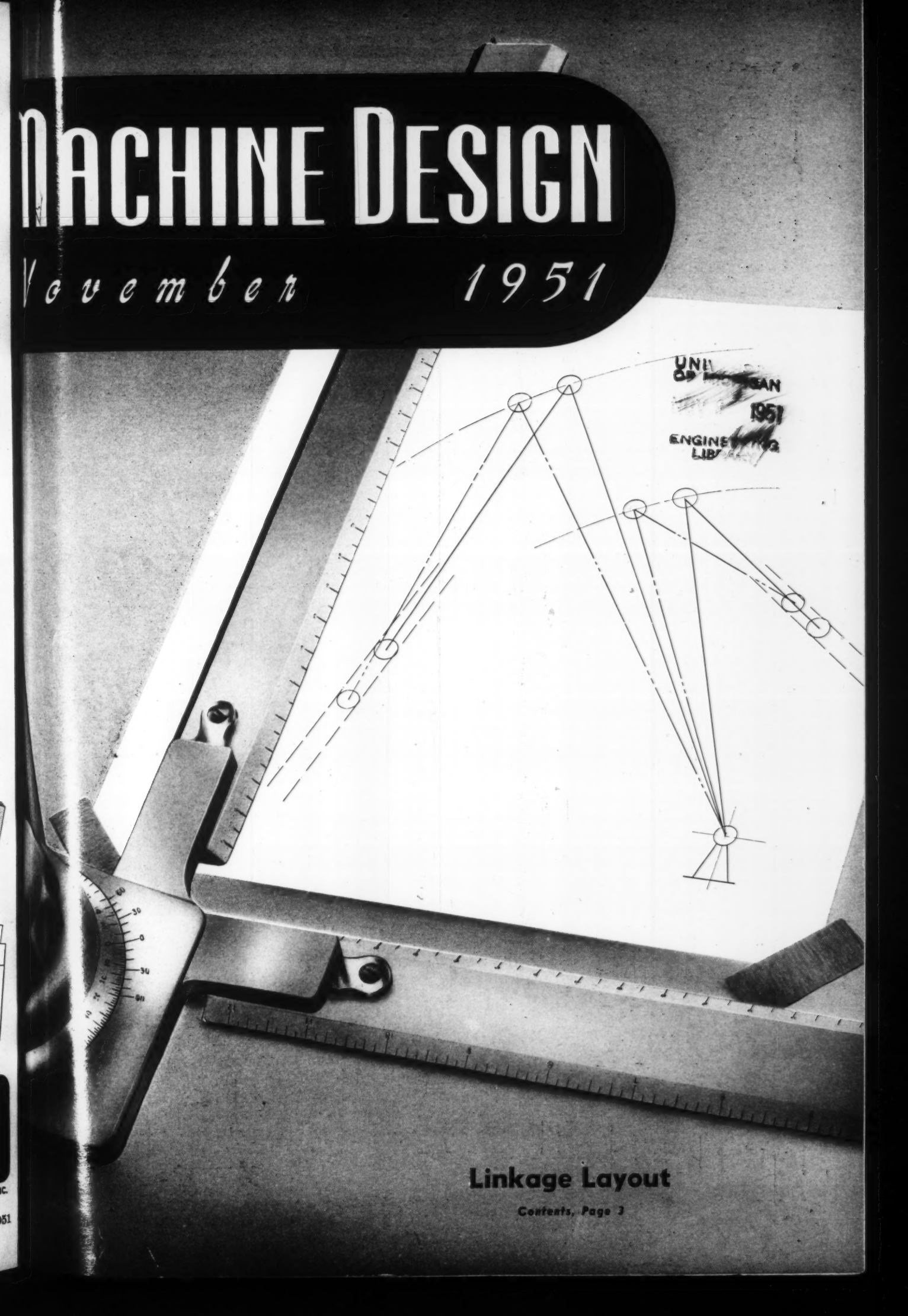
MACHINE DESIGN

November 1951



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Linkage Layout

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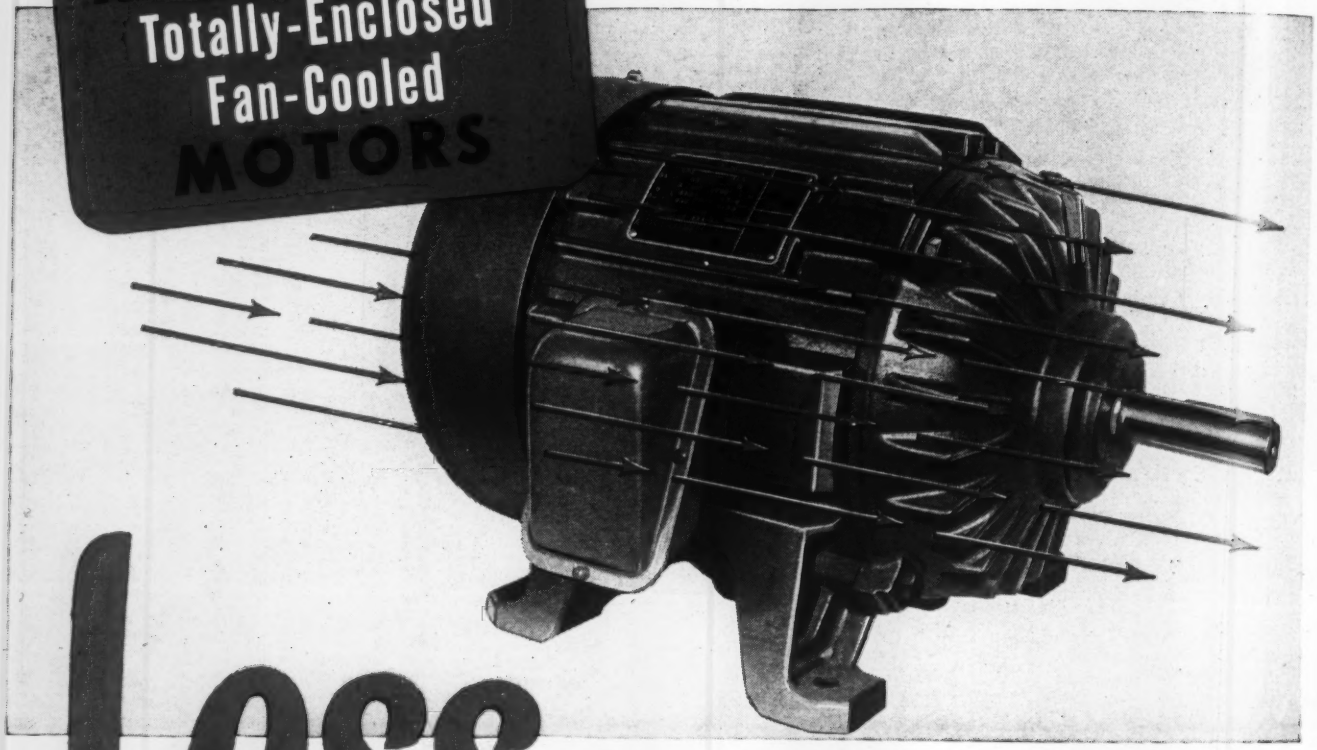
ALLIS-CHALMERS

Totally-Enclosed Fan-Cooled MOTORS



Less MOTOR CLEANING ...INSPECTION...OVERHAUL!

HERE'S A MOTOR that actually blows itself clean! Dirt is carried away by cooling air blown over the ribbed cast iron frame and bearing housings of this new Allis-Chalmers tefc motor.

Dirt can't build up to cause overheating. Concealed air passages and pockets have been eliminated. Even oily dirt that sticks can simply be wiped or blown off.

And this means savings! Maintenance costs are traditionally low on totally-enclosed, fan-cooled motors. But they're lower than ever before on the new Allis-Chalmers Type APZ tefc motor.

Rigid Construction

The frame is cast iron which has high resistance against corrosion and distortion. Bearings are pre-lubricated at the factory and should need no attention for years. Tapped holes with pipe plugs to permit regreasing and to provide grease relief are standard equipment.

Get All The Facts

The new Allis-Chalmers Type APZ totally-enclosed, fan-cooled motor is built in all NEMA standard frame sizes from 224* to 505. Also in explosion-proof type. Your A-C Authorized Distributor or District Office has complete information. Call today, or write Allis-Chalmers, Milwaukee 1, Wisconsin. Ask for Bulletin 51B7225.

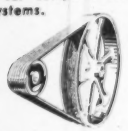
A-3426

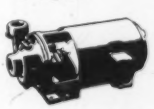
Sold . . .
Applied . . .
Serviced . . .

by Allis-Chalmers Authorized Dealers, Certified Service Shops and Sales Offices throughout the country.

CONTROL — Manual, magnetic and combination starters; push button stations and components for complete control systems.

TEXROPE — Belts in all sizes and sections, standard and *Vari-Pitch* sheaves, speed changers.





PUMPS — Integral motor and coupled types from ¾ in. to 72 in. discharge and up.

Texrope and *Vari-Pitch* are Allis-Chalmers trademarks.

ALLIS-CHALMERS

*Similar design non-ventilated motors Type APK, also available in frames 203 to 224 inclusive.

MACHINE DESIGN

THE PROFESSIONAL JOURNAL FOR ENGINEERS AND DESIGNERS

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CCA SBPE NBP

Over the Board

Introducing a New Editor

From the ranks of our readers comes the latest addition to the editorial staff of MACHINE DESIGN, Elman R. Dunn, new Associate Editor. After serving an apprenticeship and being assistant machine-shop foreman for several years with the Cumberland and Pennsylvania Railroad Co. at Mt. Savage, Md., Elman joined the engineering department of Landis Tool Co. in Waynesboro, Pa. While with Landis he worked as a designer, conducted experimental and research projects, traveled in the field giving engineering assistance to service personnel, and wrote service manuals. In 1948 Landis sent him to the machine tool expositions in London and in Paris, both to help with their own displays and to report on developments exhibited at the shows. After leaving Landis he became chief engineer of Altens Foundry and Machine Works Inc. in Lancaster, Ohio.

This Month's Cover

Inspired by the new approach to mechanism design presented by Pike, Silverberg and Nickson beginning on Page 105, Penton artist George Farnsworth has portrayed the desk of a design engineer engaged in applying these principles. Apparently, proportions of a "double-harmonic" linkage are being developed.

Production Processes

Back in 1945, associate editor Roger Bolz started out on an ambitious program of bringing to machine designers the important tools of designing for economical production. Tying up the loose ends of all the manufacturing processes important to designers proved to be a herculean task. However, some fifty monthly articles and 300,000 words later, in 1950, the job had been completed. In addition, the first half of the series of articles had been rewritten and published in book form. This month Book II, completing the job, arrived from the binders. Our announcement review appears on Page 178.

A complete and carefully documented treatise on an increasingly important phase of engineering design, *Production Processes—Their Influence On Design* is, we believe, a significant contribution to the literature of design. In completing this project, Rog created what is probably the longest integrated series of articles ever published in any technical journal. Simultaneously, this series helped establish MACHINE DESIGN as the foremost publication devoted to promoting better, more economical and practical design.

Paging Captain Video

Design engineers who follow the adventures of Captain Video (and his video rangers) on television must often have been struck by the extreme awkwardness of the main controls on the great spaceship X-9. To be sure, the operator sits at an imposing console replete with electronic communication devices which are out of this world. But in order to control some of the main functions the ranger must often stand up and reach over the console to a well-nigh inaccessible lever. Considering that what we are seeing is a glimpse into the future, it is rather discouraging to realize that the principles of operator station design so painfully learned in recent years will have been so completely forgotten. For instance, the article by Louis Davis in the current issue (Page 123) reports certain findings on the best locations and proportions of handwheels, knobs and cranks for various control torques which, applied to the control station of the X-9, undoubtedly could improve the efficiency of Captain Video's interplanetary exploits against the forces of evil.

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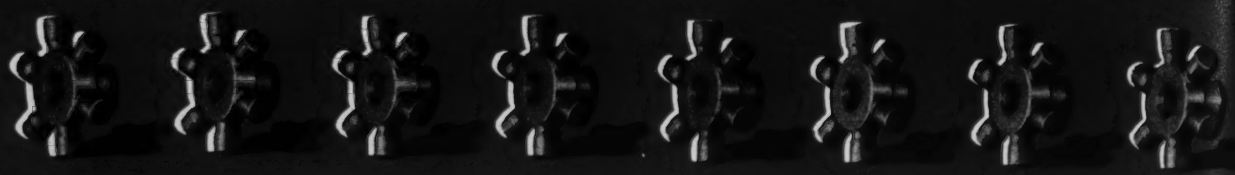
SMALL DIFFICULT PARTS MADE EASY



Correct Design

Simple designs are best, but there is no longer any need to oversimplify for the sake of producibility.

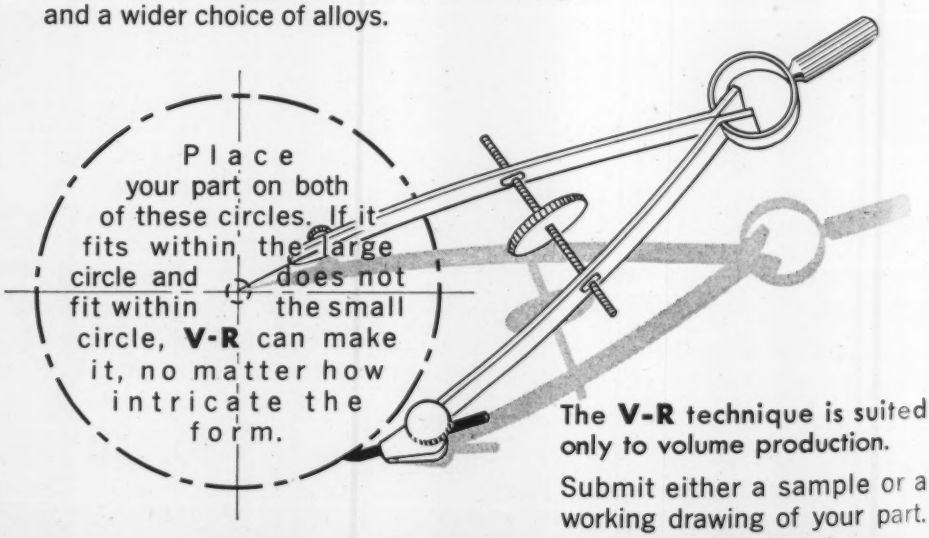
The part whose design requires multiple machining operations, or whose service conditions require a non-machinable alloy can probably be made economically by the **V-R** technique.

In addition, **V-R** may be able to make the "impossible" part.

Lower Costs

If your part is suited for the **V-R** technique, we can probably produce faster than you can, and at a saving in both tool and part cost.

You may also benefit from a sounder design and a wider choice of alloys.


Place your part on both of these circles. If it fits within the large circle and does not fit within the small circle, V-R can make it, no matter how intricate the form.

The V-R technique is suited only to volume production.

Submit either a sample or a working drawing of your part. We may be able to help you.

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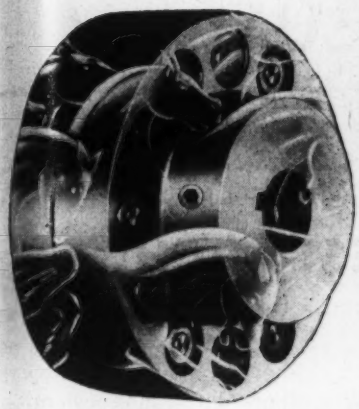

ALL THE HORSEPOWER GOES THROUGH THE COUPLING

Coupling Design of Far Reaching Importance To Plant Economy

Today's demand for high production and continuous operation emphasizes the importance of using correctly designed flexible couplings to offset unavoidable shaft misalignment on direct-connected machines. With clearances measured in thousandths, protection against expensive damage to precision machines reduces shutdowns and expensive replacements.

Ajax rubber-bushed Flexible Couplings have been recognized as standard for 30 years.

They provide positive resilient drive. Ajax Couplings are available with rubber or Neoprene bushings to suit conditions. They are made in a wide range of sizes in standard, bolt-on, brake drum and other types, with flanges made of ferrous and nonferrous metals. Write for Bulletin 48.

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TOPICS

...IN ENGINEERING AND RESEARCH

Magnesium Alloys Extruded from Powder

Magnesium alloys can be extruded from a mixture of powdered magnesium and powdered alloying metal, according to an Air Force research report. Conventionally, magnesium and the alloying metal are melted together and cast into ingots or billets which are then extruded. The powder-extrusion process gives entirely new compositions, having higher strength, improved corrosion resistance and better fabrication characteristics.

Blimp Flies Backwards

Flying backwards is the newest trick in submarine hunting. The world's largest blimp, the ZPN, has just been fitted with Curtiss-Wright reversible-pitch props, enabling pilots to reverse prop-blade angle in flight without stopping the engine. Although extended wrong-way cruises are not contemplated, the lighter-than-air craft will use the reverse feature for quick stops, maneuvering and evasive tactics.

Pigs in Baskets Aid Loading Tests

Faced with the traditional chore of hand-placing 2500 lead weights (a total of 50,000 pounds) for structural loading tests of an airplane fuselage floor, engineers at the Glenn L. Martin Co. came up with a new idea. Lead pigs were loaded into wire baskets, stacked to predetermined weights, then trundled in and out on tracks laid along the centerline of the fuselage. Time and number of men required for the job were cut in half.

Foil Containers Replace Tin Cans

Three-ply aluminum-foil containers impregnated with plastic may replace tin cans. Developed as a substitute for tin-coated steel, the material is made by coating aluminum sheets with plastic and bonding them under heat and pressure. All of the present output, according to Reynolds Metals Co., will go to the armed forces.

Magnetic Gage Measures Oil-Film Thickness

Oil-film thickness in sleeve bearings can be measured to 10 microinches with a new magnetic gage. Based on the principle that change in distance of the shaft from two fixed coils causes a variation in inductance between them, the National Bureau of Standards gage requires no physical contact and can be used at speeds exceeding 10,000 rpm. From two to six probes are fastened rigidly to the bearing at the point where the shaft enters the bearing.

Photosensitive Glass "Chemically Machined"

Complex parts, channels for "printed" electric circuits, or perforated holes numbering several thousand to the square inch, can be etched into a new opal glass developed by Corning Glass Works. The glass is photosensitive throughout, and is exposed by printing a design from an ordinary photographic negative with ultraviolet light. A milk-white image is then de-

BUSINESS IN MOTION

To our Colleagues in American Business . . .

The fact that a Revere Distributor is now celebrating its 125th anniversary year is an indication of the service the company has given its customers through those years. It is also another proof of the essential function performed by distributors for American industry. Most goods, whether industrial materials such as copper and copper alloys, aluminum alloys, iron and steel, or consumer articles such as refrigerators, radio and television receivers, kitchen utensils and ranges, go through the hands of distributors. Generally speaking, only the large buyers are in a position to purchase direct from manufacturers, who do not find it economical to handle the smaller orders. Yet those orders when pooled in the hands of an organization set up to handle them attain sizable totals, and hence a good distributor account is exceedingly attractive to a large manufacturer such as Revere.

A distributor serves not only the factories from which he buys. He also performs an invaluable service to his customers by making quickly available to them the products they require. A machine shop, for example, may need only a few hundred pounds of brass rod; there is a distributor within easy reach who can furnish it almost immediately. Or a contractor may want a few pieces of steel pipe and a thousand feet or so of copper water tube. Again, the distributor has them. A metal products distributor has to carry such items and an infinite number of others. The Revere Distributor who started in business 125 years ago actually has in stock 53,000 different items, cataloged, indexed, and held in warehouses ready for immediate shipment throughout its territory. Each month this stock is drawn upon by 5,000 to 8,000 customers, each order relatively small. There are many Revere Distributors with similar stocks and offering equal service.

To keep this distributor's warehouses filled with a balanced inventory, 18 people are required in his purchasing staff, which includes specialists in various kinds of materials, machines, tools and supplies. And to serve customers with information, quotations and the like, 25 salesmen are on the go constantly, calling on manufacturers, contractors, builders and stores throughout the busy industrial area in which the distributor operates. The large business done by the company is in great contrast to that of 125 years ago, when it was little more than a hardware store. The enterprise has grown in the American tradition of freedom to prosper in accordance with the principles of reliability and efficiency, fair dealing and integrity in performing a desired function.

Revere Distributors are selected for their ability to serve, and also chosen as to location, so that no matter where you are in this big country of ours, there is a Revere Distributor within easy reach. Today metal stocks may be short due to defense demands but manufacturers are doing everything possible to keep distributors supplied.

If you buy from distributors we suggest you remember that they are not only "central stockrooms," but have a great deal of special knowledge about the products they sell and can give you much helpful advice. Not only that, through the Revere Distributors you can be put in touch with the Revere Technical Advisory Service, which will cooperate with you on matters concerning the selection and fabrication of the Revere Metals. Our distributors, and those of every other manufacturer, render many essential services, both to those to whom they sell, and to those from whom they buy. The distributor system as it operates in the United States arose in response to the need for it. Today it fulfills that need more effectively than ever before.

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TOPICS

veloped by heating the glass to 1200 F for about two hours, and is etched out with hydrofluoric acid. Depth of acid penetration, from shallow etching to complete erosion, is controlled by variations in tone of the negative and in length and intensity of light exposure.

Low-Alloy Boron Steels Reported Adequate

Actual tests reported recently by SAE members indicate that in most applications low-alloy boron steels are completely adequate and equal to their rich-alloy counterparts. New boron steels specified by AISI have the same hardenability as former alloy steels, but contain much less nickel and molybdenum. Addition of one ounce of boron to one ton of steel saves nearly half of these critical alloying ingredients.

Survey Shows Growth in Research

Nearly half the firms contacted in a recent survey had used or expected to use outside research organizations in 1951 to obtain specialized knowledge or special services. Only 40 per cent of the 400 business executives and research directors surveyed by Evans Research and Development Corp. felt that their companies had sufficient research personnel. Slightly more than half will obtain new people from universities, less than one-fifth from other industries. About 75 per cent report budgets based on "as-needed" requirements rather than fixed sums.

. . . IN GOVERNMENT AND INDUSTRY

New Priority Symbol Established

Urgently needed defense items will be labeled with a new symbol, DX, as an emergency measure to speed up delivery. Producers receiving DX orders will be required to fill them first. To be applied by a central NPA headquarters unit on special request from the agency needing the rating, the symbol is expected to be used only on top-priority programs.

No Strike Since 1937

Swiss mechanical engineering and metal industries haven't had a labor strike in fourteen years. The reason, according to Dr. F. Oederlin, director of engineering for a Swiss firm, is the excellent antistrike agreement existing between industries and trade union. The agreement stipulates that disputes should be settled as far as possible in the plants themselves, and also that each party must deposit caution money from which heavy fines may be deducted if the agreement is violated.

Materials Shortages Cause Delivery Delays

Precision mechanical spring production is reported to be down 15 to 35 per cent from last spring. Cause is lack of steel, brass, and wire-mill products. . . . Deliveries on specialty transformers, running from 1 to 2 months before Korea, are now 3 to 12 months. Shortages of copper wire, silicon and carbon steel are blamed. . . . Unfilled order backlogs of 4 to 12 months in power-transmission and conveyor chains are due to insufficient steel and unbalanced steel deliveries.

Scrap Drive Gathers Momentum

Aiming at an end-of-the-year goal of 36 million tons of scrap, industry and government departments reported a constantly increasing yield, even from sources not usually regarded as large iron and steel consumers. Necessity for larger supplies of scrap is pointed out by the fact that the most efficient charge for an open-hearth furnace consists of 50 per cent scrap. Whenever a ton of scrap is used in place of pig iron, more than four tons of coal, iron ore, limestone and other raw materials are saved.

Mechanism Design—Systematic or Haphazard?

NOWHERE in a design engineer's work is the creative aspect more challenging than in the devising of mechanisms or mechanical motions. By ingenuity or invention, pioneering minds have created many useful linkages which are being copied or adapted in engineering design every day. Well established methods of analysis enable engineers to check designs so arrived at, but there are limits to the time that can be devoted to such haphazard, cut-and-try methods. Without the "flash of genius" or, perhaps, the available time or perseverance of some inventors, today's average designer works under somewhat of a handicap.

We are told that European engineers, seeking an answer to the same problem, are well along the road to "kinematic synthesis," a sixty-four dollar expression for a procedure whereby the designer assembles his requirements, turns a crank as it were, and comes out with mechanism proportions exactly tailored to the job at hand. Whether or not this method is really practical—and those in contact with European engineering assure us that it is—the fact remains that the procedure has so far eluded engineers in this country, because it is not widely known or used here.

In the absence of a truly synthetic approach, American engineers are turning to practical methods based on the systematic presentation of data. Analogous to the steam tables used by power-plant engineers, these procedures depend on the compilation of chart books or atlases containing mechanism performance curves for the useful range of proportions. It is then a comparatively simple matter to find in the atlas the mechanism which will best match the requirements of the job.

In a significant article published in this issue three Raytheon engineers tell how this approach, which has been used in the design of computing mechanisms, can be adapted to the general requirements of a variety of machines. Extending the matching technique by the application of corrective cams to smooth out minor discrepancies between requirements and actual mechanisms, they point the way to quicker and better mechanism design procedures. Because the approach is eminently practical it should have considerable impact on the thinking of design engineers and result in the creation of greatly improved mechanisms.

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EDITOR

ADHESIVES in

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Photo, courtesy Minnesota Mining & Mfg. Co.

Fig. 1—Inflatable seal tube around wind screen of Republic F-84 Thunderjet fighter is sealed to metal with adhesive

AVAILABILITY of outstanding high-strength adhesives has suggested to designers the possibilities of employing bonded assemblies in machine construction. There is sound justification for this interest because the performance of structural assemblies utilizing adhesives has been good. It must be realized, however, that new problems are introduced by "chemical fasteners". By acquiring greater familiarity with the characteristics of modern adhesives, the designer is in a better position to specify the correct material and to create designs which will utilize the full benefits possible from bonding agents.

Adhesives are better known for their uses with wood, paper, cloth, and cellulose materials. Many adhesives of natural and synthetic origin have been used for these purposes. However, in this article attention is focused upon the more recent, modern adhesives which have demonstrated the facility of bonding to metals, rubber, thermosetting plastics, and other materials, *Figs.* 1 and 2. These adhesives, used in many structural assemblies, may be referred to as structural adhesives. They have high bond strength, and are capable of resisting tensile, shear, and impact stresses found in structural assemblies. They stem from many sources, particularly synthetic and natural rubber, as well as thermosetting resins. A representative group of adhesives which have potential value in the design of machines appears in TABLE 1. Much interest and publicity has been focused upon the thermosetting resin modified rubbers for adhesive bonding (Cycleweld and Plastilock). Presence of the rubberlike material allows for differences in thermal properties and enhances impact strength. The thermosetting resin component adds to tensile strength, particularly at high temperatures. Thermoplastic resin bases modified with thermosetting resins have likewise demonstrated outstanding properties, such as in bonding aluminum alloy sheets to laminated phenolics, *Fig.* 2.

SELECTING AN ADHESIVE: No one type of adhesive may be cited as offering an outstanding bond with all classes of material. Although several may be rightly classified as general-purpose materials, the selection and application of an adhesive should be governed by several considerations.

1. *Materials to be bonded:* Generally, dissimilar materials offer greater bonding problems. There are not many examples of true chemical bonding, which implies the establishment of strong valence bonds between the adhesive and surfaces to be bonded. Some adhesive assemblies are aided by mechanical bonding, achieved by roughening the mating surfaces. TABLE 1 suggests adhesives to be used with various materials.

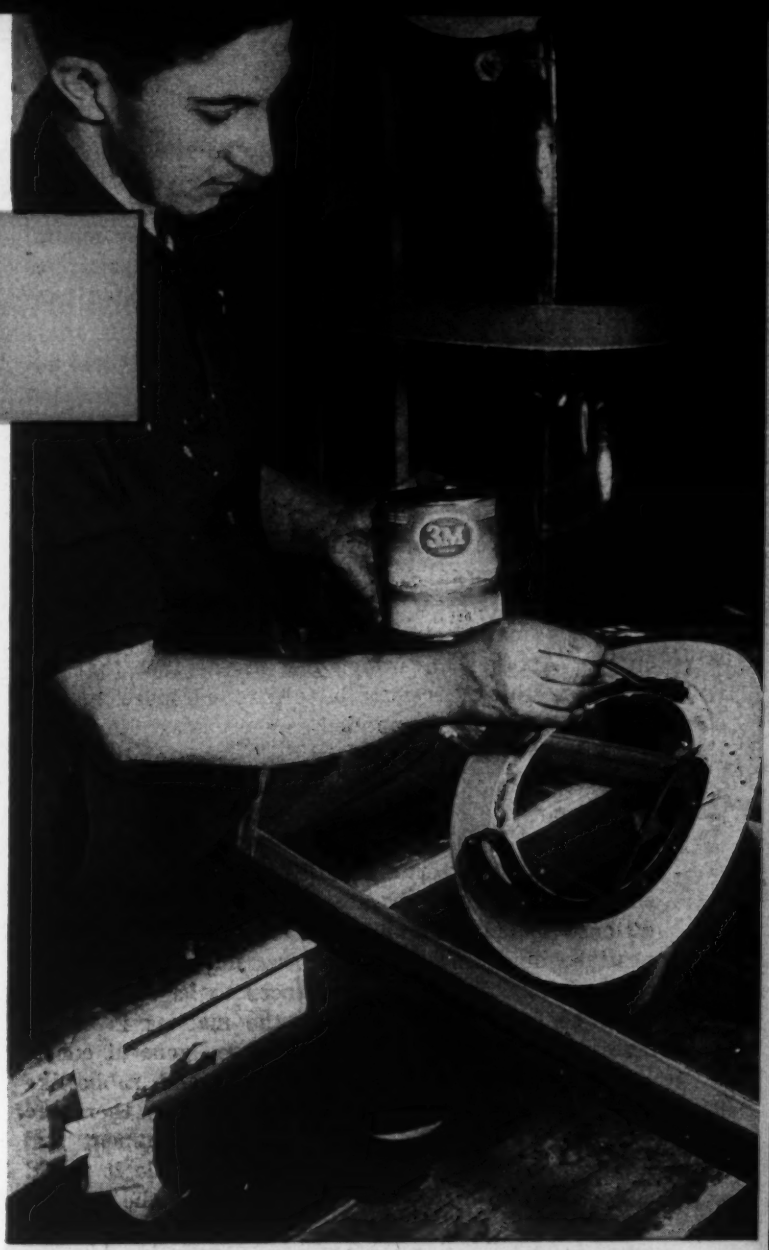
2. *Surface cleanliness and preparation:* Perhaps no factor is quite so important to the realization of high strength in an adhesive bond as the cleanliness and preparation of the surfaces. Several methods for cleaning and preparing surfaces prior to adhesive bonding are written into government specifications covering the assembly of structural members. Acid etches for steel surfaces, acid-dichromate bath for aluminum alloys, and acid cyclizing of rubber sur-

faces are representative treatments prescribed. More complete procedures appear, for example, in Military Specification S-5002 and in various specifications prepared by adhesives manufacturers.

3. *Temperature of bonding:* Several of the more successful metal bonding adhesives require high temperatures for bonding, ranging from 250 to 400 F. The higher the bonding temperature, the shorter the cure time, as shown in *Fig.* 3. However, greater strength may sometimes be reached at intermediate temperatures. The designer must not overlook the effect of bonding temperature upon the properties of metals undergoing bonding; revised heat treating schedules may be needed for nonferrous metal components. When no elevated temperatures may be applied, a catalyzed room-temperature setting adhesive must be employed. Adhering primer coatings on metal surfaces are frequently desirable to develop a surface to which the low-temperature setting adhesive will bond.

4. *Volatiles in the bonding agent:* When porous surfaces are being bonded together there are ample channels for the escape of volatiles from adhesives. Frequently, however, as in bonding metals, plastics, or rubbers, this escape is not possible. Thorough predrying or precuring may then be recommended by the manufacturer before assembly is effected. Heat and pressure are necessary to promote a bond between surfaces previously coated with the adhesive. One hundred per cent solid adhesives such as ethoxylines, epichlorhydrin types, furanes, and polyesters will demonstrate true gap-filling qualities. Frequently in the bonding of machine elements, large gaps may be present along the proposed adhesive plane. Good gap-filling materials are recommended for promoting a strong, continuous bond capable of absorbing its share of the load.

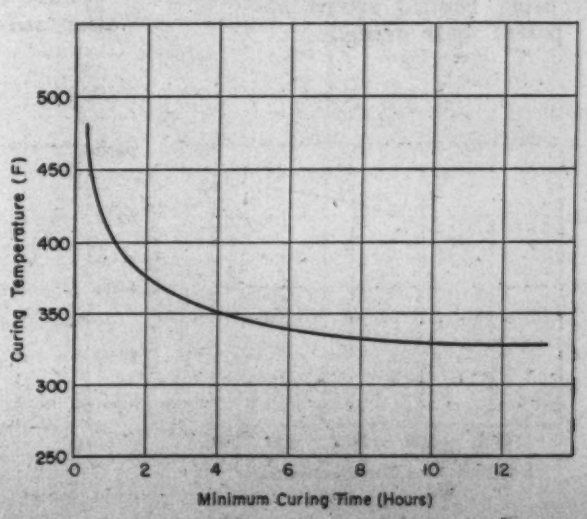
5. *Pressures required:* Curing of an adhesive is primarily a function of the temperature, time of cure and catalytic agents present at the glue line. Pressure is only incidental, and will not materially influence the cure time for a glue line of specified thickness. However, sufficient pressure should be employed to insure firm and complete contact of all surfaces being bonded. When this pressure is attained, whether it is 10 or 1000 psi, optimum properties will result from the adhesive selected. Pressure required



Photo, courtesy Minnesota Mining & Mfg. Co.

Fig. 2—Above—Brush - applied adhesive bonds rubber gasket on glass canopy access door of F-84 fighter aircraft

Fig. 3—Below—Higher bonding temperatures require shorter curing time, as shown by this curve for an ethoxyline resin adhesive



by the assembly may have to be maintained during cooling for hot setting adhesives that do not exhibit sufficient bond strength at high temperatures. However, thermosetting resin adhesives and their modifications will generally permit removal of assemblies from the press, while they are still at elevated temperatures.

6. *Physical form of the adhesive:* Structural adhesives may appear either in a liquid state, powdered form, as dry film, or combinations of these forms. Physical form may have an influence on the choice of an adhesive. Those which are applied in liquid form frequently require a precuring scheduled before cure, which complicates and prolongs assembly. Machine elements can usually be bonded with least difficulty by dry films which, during their processing by the materials manufacturer, have been adequately precured. Another advantage lies in the fact that the glue line thickness may be controlled more readily when the adhesive is applied as a prepared film. One method for curing adhesives makes use of high frequency waves applied with portable, fast-setting hand equipment.

PROPERTIES OF STRUCTURAL ADHESIVES: The properties of structural adhesives depend upon many conditions including ambient temperatures, environmental influences (prior and current), chemical nature of the adhesive and surfaces to be bonded, geometry of the glue line, and the manner in which stresses are applied. The first three general conditions are obvious. Organic plastics and rubberlike materials and the adhesives derived from them are known to vary with temperature, environment and the innate qualities of the material. While it would serve no immediate purpose to tabulate the properties of all adhesives listed in TABLE 1 at various temperatures, a useful guide to acceptable practice is contained in TABLE 2, which is prepared from USAF Specification 14164. Figures shown in this table represent minimum values. For example, some adhesives demonstrate shear strengths beyond 5000 psi, or beyond the tensile load which will rupture some sheet materials when pulled apart.

Standard test methods which may be used in evaluating structural adhesives have been established by the ASTM. These test methods should be closely followed because glue line conditions and manner of stress application may introduce variables which will not permit comparisons to be made, unless standard procedures are followed.

What is less obvious to machine designers engaged in computing stress limits is the dependence of adhesive strength upon the geometry of the glue line, assuming precure, temperature, and time of cure are in an optimum range. For example, shear strength is shown as a function of metal thickness being bonded and amount of overlap at glue line in *Figs.* 4 and 5. Apparent shear strength is affected by bonding when simple overlap is used, *Fig.* 6, and both shear and tension stresses are present. As the metals being bonded increase in thickness, the tension stress component is less of the total stress, because of less bending, and higher apparent shear strengths are realized. Similarly, when the overlap is decreased, the apparent unit shear strength (shear load to fail divided by shear area under stress) increases. This situation is particularly apparent for adhesives which are fairly rigid when cured because the bead or fillet of adhesive formed at the edges of the glue line plays such an important part in realizing optimum strength. In shorter overlaps, the significance of this bead as a proportion of the total adhesive bond becomes greater. Strength of such assemblies has been enhanced by extending the length of the beaded portion by serrating one of the overlapping contact sheets, as

Fig. 4—Thickness of aluminum sheet being bonded affects apparent shear strength

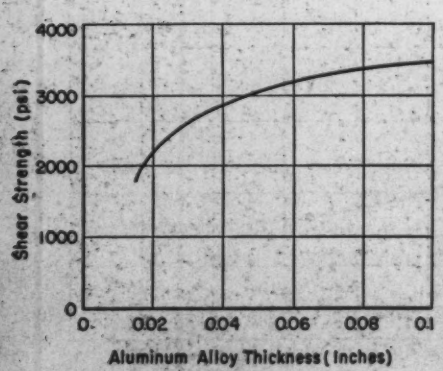


Fig. 5—Effect of bond area of ¼-inch steel plate on specific shear stress, using vinyl-phenolic adhesive

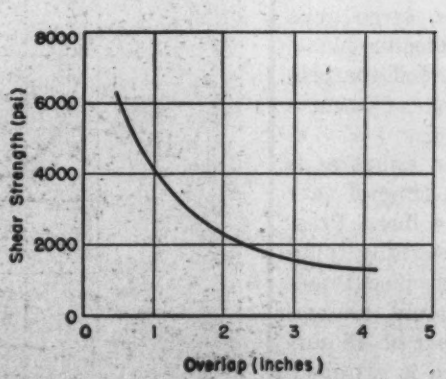


Fig. 6—Stresses in lap joint hav both shear and tension compon ents. Increasing length of bea ed portion of joint by serration lower sketch, increases strengt

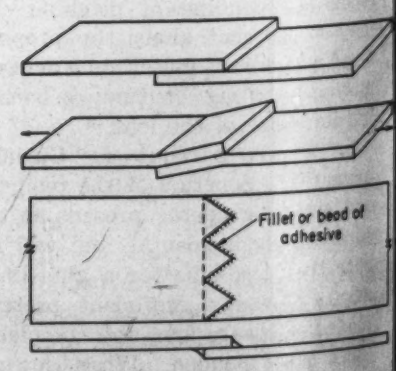


Table 1—Adhesives with Potential Machine Design Applications

Type of Adhesive	Method of Curing	Bonding Surfaces Recommended	Significant Qualities	Representative End Uses
Urea and melamine formaldehyde	Hot and cold setting	Wood, paper, textiles	Water as solvent, low cost	Plywood and wood structures
Resorcinol formaldehyde	Hot and cold setting	Wood, paper, acrylics, nylon, thermosetting plastics	Neutral pH of glue. Good weatherability	Plywood and wood structures. Edge attachments for acrylic canopies
Phenol formaldehyde	Hot and cold setting	Wood, ceramics	Boilproof and weatherproof	Luting compounds for glass bottles, hot set types for plywood
Furane resins	Cold set	Thermosetting plastics, ceramics, acrylic	High solids content, gap-filling	Coatings for wound wires, phenolic laminates, grouting for chemical tanks
Cyclized rubber, neoprene rubber, chlorinated rubber	Solvent release	Textiles, paper, rubber	Good tackiness	Metal to rubber assemblies
Phenolic modified synthetic rubbers	Hot set	Metals, rubber, thermosetting plastics	Good hot-strength, flexible	Metal to metal and rubber
Ethoxyline resins, epichlorhydrin—bisphenol resins	Hot set	Metals, rubber	Good strength at low and moderate temperatures	Metal to metal assemblies
Polyvinyl acetate	Solvent release	Wood, paper, textiles	Emulsion and solvent types. Good thermoplastic	Uses on porous surfaces
Vinyl and phenolic resins	Hot set	Metals, rubber	Liquid resin spread followed by vinyl powder	General purpose and metal bonding
Polyesters	Hot set	Polyester laminates	Clear, no volatiles	Radomes, glass cloth polyester laminates

shown in the lower sketch of *Fig.* 6.

High-temperature bonding introduces complications such as warping if materials of different expansion coefficient are being bonded or if there is a considerable mass difference between the two parts. Pressures should be sufficient to prevent any untoward effect from rupturing the bond. If a metallic member is bonded to a nonmetallic, the designer should maintain a balanced condition to minimize warping. For example, a thin metal foil applied to only one face of plywood would cause considerable warping, whereas uniformity is maintained when the metal foil is applied to both sides.

APPLICATION ANALYSIS: The following applications of structural adhesives show the wide utility of modern adhesives on various machines and products.

1. *Assemblies difficult to reach:* If in the assembly of machine components it is difficult to apply the proper back-up pressure to screws or rivets the methods of bonding through adhesives may be considered. Although many "impossible" situations have been solved through blind rivets or special screw machine products, the adhesive-bonded assembly may offer certain advantages. While speed of assembly may favor mechanical attachment devices, the assembly may be such that vibration would lessen the tightness of fit, whereas the adhesively bonded assembly would not suffer under these conditions. For example, the reinforcing strips used on sheet metal parts in *Fig.* 7 are more effectively assembled with the aid of adhesives. These situations frequently arise in the development of sheet metal aircraft struc-

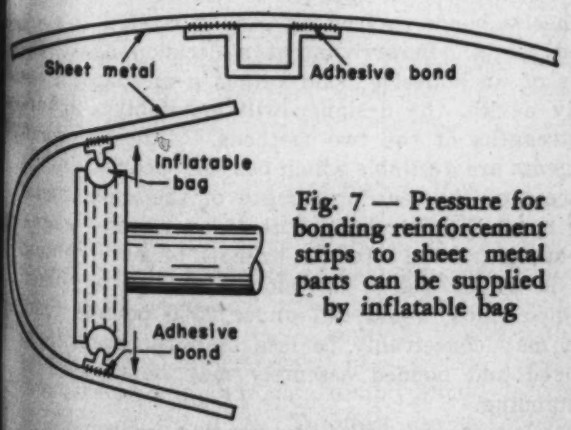


Fig. 7 — Pressure for bonding reinforcement strips to sheet metal parts can be supplied by inflatable bag

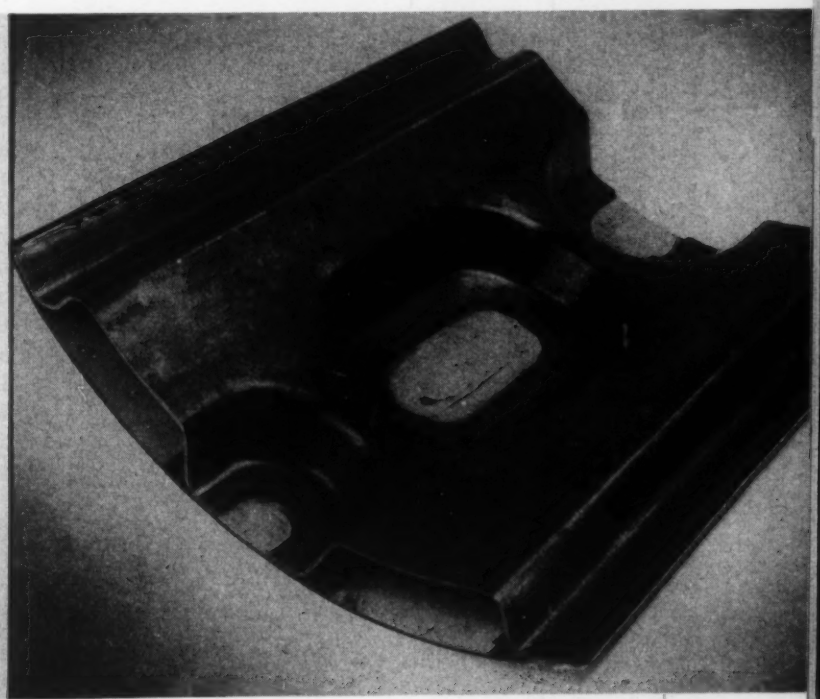


Fig. 8.—Right—Panel construction shows sheet metal section strengthened with laminated reinforcement bonded to back

tures, or in the design of air conditioning equipment. A section of panel with reinforcing member bonded in position is shown in *Fig.* 8.

It may be objected that pressure is required for the adhesive assembly. This is true, though in the assembly device shown in *Fig.* 8 a novel method of applying bonding pressure is used. An inflatable bag or tube maintains the close relationship required, a procedure not possible with riveting. The salient principle is, of course, that an inflatable membrane placed within an enclosed space provides sufficient pressure for bonding purposes. At the completion of assembly, the membrane may be withdrawn.

Use of adhesive bonding in assemblies difficult to reach is further illustrated by the design element shown in *Fig.* 9. An example of such an assembly is the sleeve protector around a casing used in oil well drilling equipment, where the size and length of the pipe would preclude screw threads at the region of assembly. The problem is nicely handled by brazing or cementing. Brazing is feasible only if two metals are to be joined or if the heat required offers no service handicap. Otherwise adhesive bonds may be employed, particularly if nonmetallics are to be joined to metal. Bonding cellulose sponge to metal *Fig.* 10, is another difficult assembly which can be bonded satisfactorily.

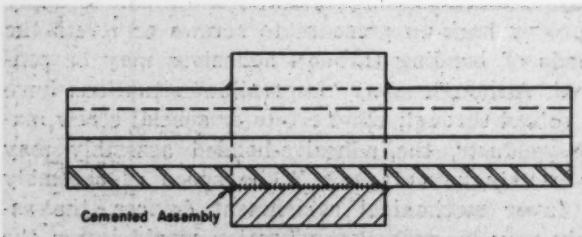


Fig. 9—Above—Protector sleeve for oil well casing is made by cementing insulating bushing to steel tubing

Fig. 10—Below—Cellulose sponge is bonded to canvas backing and backing to steel plate to form mop head

Photo, courtesy Minnesota Mining & Manufacturing Co.

2. *Where screws or rivets are objectionable:* There are a few but nevertheless important design applications where the physical presence of screws or rivets offers serious objection. An excellent example, perhaps, is the adhesively bonded brake lining. The greater longevity of this brake lining over earlier types is due to the absence of rivets, permitting maximum utilization of the brake lining. The many automobiles serviced in this manner bear witness to the efficacy of such assemblies.

Wing and fuselage skins of high-speed aircraft and guided missiles should present as smooth and as unbroken a surface as possible. Here adhesive bonding has offered practical solutions to the reduction of drag and the enhancement of efficiency. Uniform adhesive bonding also eliminates dimples or wrinkling which may occur on thin sheet metal if the attachment means are relegated to a few selected points rather than a uniform distribution. Adhesives contribute in no small measure to a well streamlined assembly. Structural members reinforced with honeycomb cores are all adhesively bonded.

Table 2—Minimum Requirements of Metal to Metal Structural Adhesives
(USAF Spec. No. 14164)

Test	Temperature (F)	Minimum Strength (psi)
Shear strength	−65 to −70	2500
Shear strength*	72 to 76	2500
Shear strength	178 to 182	1250
Fatigue strength	−65 to 70	650
(3600 cpm—axial tensile load)	72 to 76	650
Long-time tensile	72 to 76	1600
strength	178 to 182	800
Impact strength	72 to 76	10 ft-lb
	−65 to −70	5 ft-lb

* Shear strength (at 72 to 76 F) after:

30 days salt spray exposure	2000
30 days immersion in tap water	2000
7 days in hydraulic oil	2000
7 days in hydrocarbon fluid	2000

3. *When superior strength is required:* Strength of adhesive bonds may be superior to riveted or spot-welded joints. In arriving at a decision as to the merits of an adhesive bond versus a mechanical assembly device, the designer will inevitably compare the strengths of the two methods. Adhesive bonding agents are available which possess shear strengths in excess of the tensile strength of the sheet metal being bonded, particularly with thinner metal gages. For example, if the ultimate strength of an aluminum alloy is 80,000 psi, a one-inch wide test specimen 1/32-inch thick would fail under 2560 pounds load, which may conceivably be less than the shear load a lapped and bonded assembly may be capable of withstanding.

3. *Sealed seams:* Adhesive bonding, continuous in its application, provides a sealed seam impervious to liquids and gases. This fact may be utilized to full advantage in the design of fuel storage tanks, for example. It would be necessary under the circumstances to explore carefully the chemical resistance of the bond toward materials to be contained in

the tank in order to ascertain the adequacy of the adhesive in this dual role.

In many designs, it may be more expedient to employ a sealing strip for the seams to permit adjustment to variations in the mating surfaces. In that event the employment of a rubberlike extrusion or stripping is a logical solution, *Fig.* 11. The stripping may then be fastened to one of the mating surfaces by an adhesive bond, which will permit full utilization of the cushioning action. On the other hand, mechanical attachment devices for the sealing strip would be objectionable because they may detract from the uniform sealing action by areas of compression at the attachment points.

Sealing strips adhesively bonded to a cover are used in assemblies for pressurized equipment used at high altitude, *Fig.* 1. Similar sealing problems are solved in refrigerator apparatus and in openings between chambers at different pressures. An adequately bonded sealing strip affords a sound basis for an effective design.

The problem of sealed seams may be exemplified by another design where a synthetic rubber O-ring is bonded to a molded phenolic plastic tubular member. This assembly serves important functions in sealing pressures on hydraulic and pneumatic equipment. The assembly problem is complicated by the curvature of the O-ring sealing members, which may be designed to provide a seal against a cylindrical member. An adhesive bond appears to be the only effective way of keeping the O-ring in its proper position.

4. *Appearance considerations important:* Dissimilar materials may be adhesively bonded to achieve improved appearance of the machine or product, *Fig.* 12. Too, a manufacturer of a special machine with a steel chassis may decide to employ a face of a colorful, decorative laminated plastic. It may not be expedient due to the limited number of units involved to redesign or restyle the entire machine housing in a molded phenolic. One manufacturer of a special-purpose machine has specified the bonding of a sheet of colorful laminated phenolic to the face of his machine with a phenolic-butadiene-acrylonitrile adhesive. A trim conceals the bond along the edges. An added advantage is the superior insulating properties offered by the decorative face. This is of decided importance where maximum insulation protection is required, as on high-voltage equipment.

Bonding Decorative Trim

Decorative stampings or trim may be adequately positioned with the aid of heat sensitized adhesives. The adhesive, applied in solution form, is given ample time to air-dry and to permit all volatiles to evaporate. This is important because the presence of volatiles in a nonporous assembly would decrease the strength of the bond. To effect the assembly, either the stamping or the part is heated to a temperature high enough to soften the adhesive, and the surfaces are pressed together while still hot. As the components cool, satisfactory bonding ensues. Modified vinyl base adhesives have proved acceptable in as-

(*Concluded on Page* 192)

Photos, courtesy Minnesota Mining & Manufacturing Co.

Fig. 11—Top—Sponge rubber weatherstripping being applied to taxicab door, with adhesive sprayed onto door with an air gun

Fig. 12—Above— Coated leatherette panels being bonded to portable radio cabinets

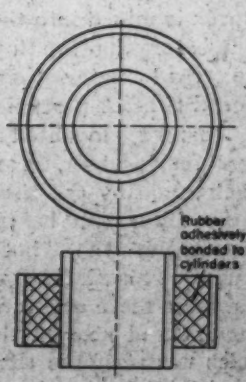
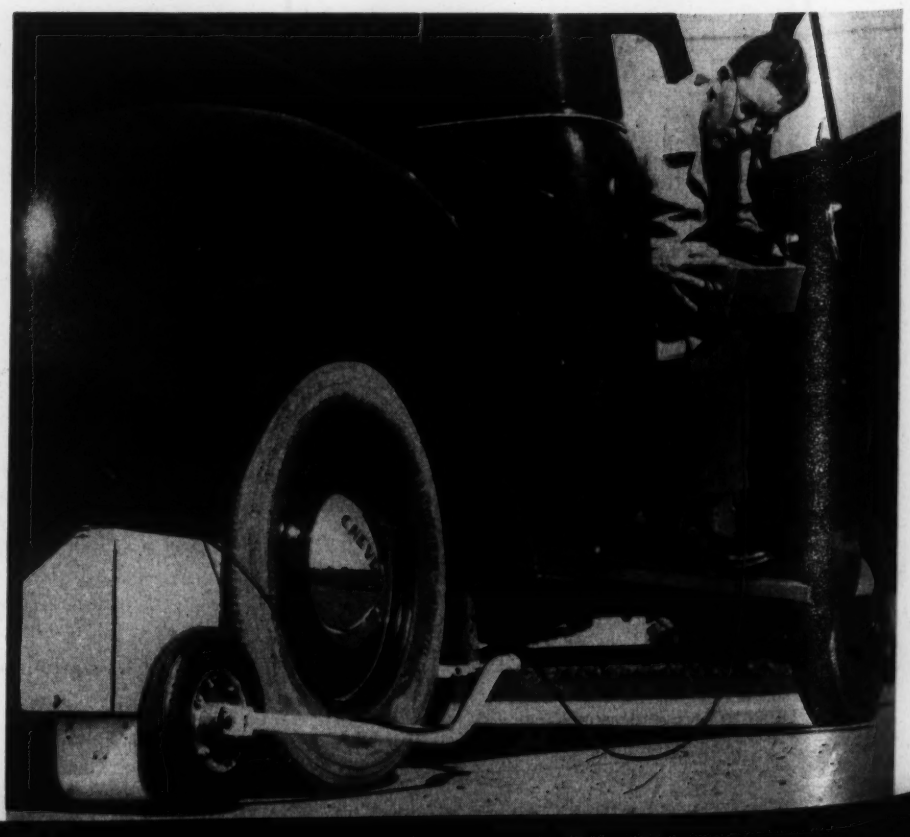


Fig. 13—Right—Assembly for vibration absorption uses rubber bonded to two metal cylinders to withstand shear and torsion stresses

SCANNING the Field For Ideas

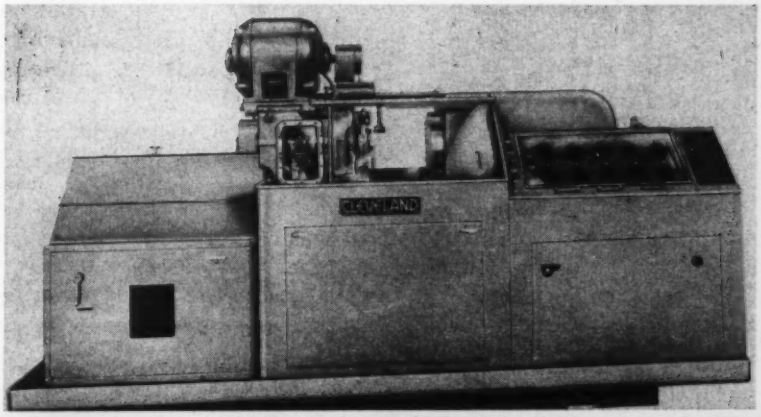
High - speed photography, aided by oscillographic images recorded simultaneously with the mechanical images on the same film, will broaden the usefulness of this method of motion analysis. Developed by Eastman Kodak Co., the camera, left, has a second lens on its side to record the trace of a cathode-ray oscillograph through the back of the film while the mechanical aspects of the subject are being photographed on the front. Data such as strain, acceleration, vibration or other signals are thus easily correlated with the position of the mechanism. Inasmuch as the film travels in a vertical direction, only the horizontal deflecting circuit of the oscilloscope is used.

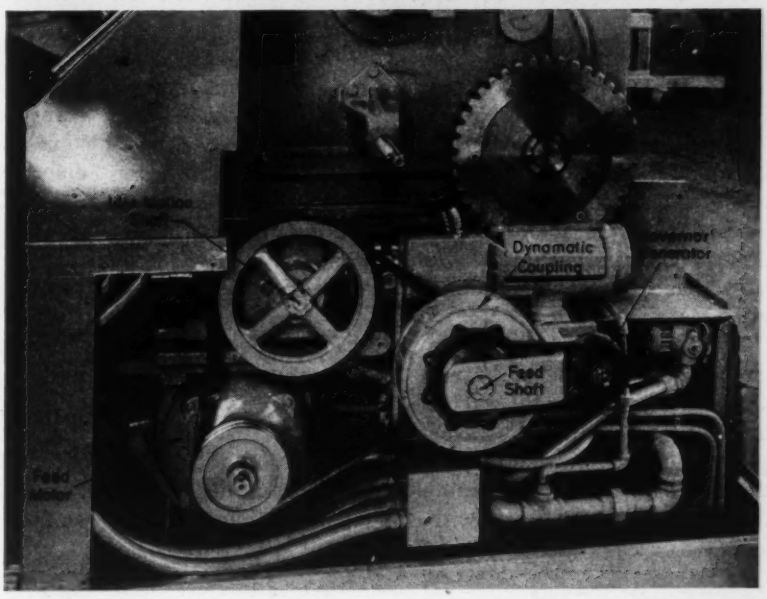
Radioactive materials are being employed by the B. F. Goodrich Research Center to give instantaneous data on tire wear and to evaluate quickly the effect of various factors. Radioactive phosphorus is mixed into the compound for the top layer of the tread material for the special tires. A portable Geiger counter, mounted on a small cart, right, scans the track made by the tire. Also, X-ray films can be used to photograph the "hot" tire tracks. This latter method measures more accurately the amount and size of the particles worn off the tires than does the Geiger counter method of measuring.



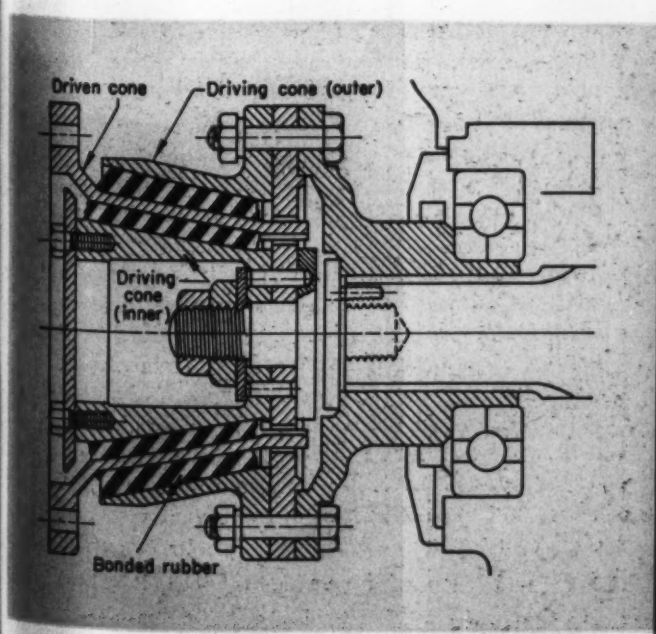
Eddy-current clutch, driven by a conventional feed motor, controls the turret feeds in the single-spindle automatic illustrated at right, without the necessity of making cam changes. Designed by The Cleveland Automatic Machine Co., this versatile and quickly adjustable drive employs a control panel with ten dialed rheostats, rotary selector switch, shifting disk, and shifting mechanism to preset the feed sequences driven by the constant-speed a-c motor and eddy-current clutch. With the spindle speeds and the feed for each turret tool position determined, dial settings for each rheostat can be established accordingly. As shown in the closeup view of the drive, right, the a-c feed motor drives both the field member of the clutch and the idle motion or rapid traverse of the machine. Speed of the inner member of the clutch is controlled by the rheostat settings. The rotary selector switch, with ten sets of contacts driven by the camshaft, selects the proper rheostat for each turret position. Thus separate and infinitely adjustable feeds can be preselected for both forward and return motion of each of the five turret positions. The feed rate for any tool can be changed while it is cutting, making it possible to adjust a job easily to maximum production.

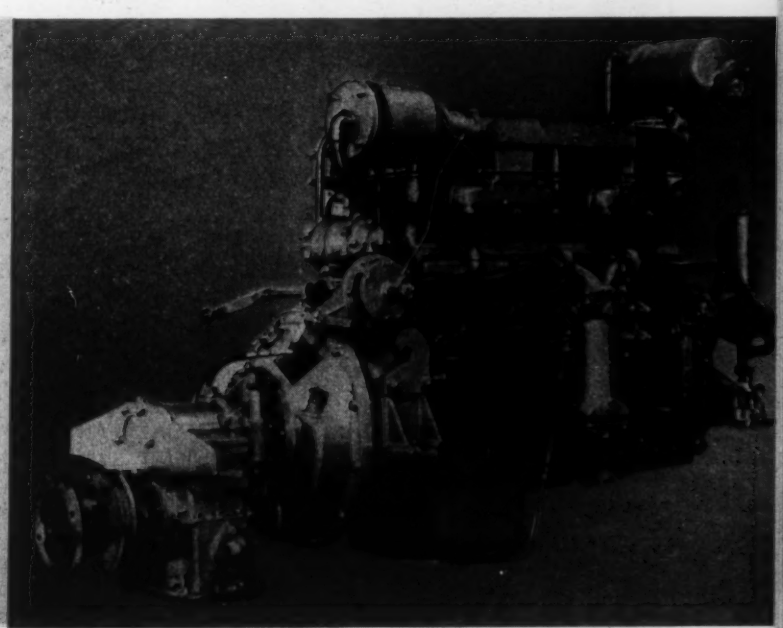
The feed drive mechanism is simple and is easily accessible for maintenance purposes. A disk type friction clutch, controlling the feed and rapid traverse, is shifted automatically by a small hydraulic cylinder. This cylinder is controlled by a solenoid valve which is actuated by precision limit switches tripped by adjustable dogs on the shifting disk.





Double-cone coupling, below, is capable of transmitting power where torsional deflections of 5 to 10 degrees are encountered, yet has sufficient radial stiffness to be self-centering so that one of the shafts does not need a bearing close to the





coupling. Three concentric conical sleeves bonded with rubber form the coupling, the inner and outer sleeves being coupled to one of the shafts and the intermediate sleeve to the other. In the marine diesel application shown, the inner and outer cones are the driving members.

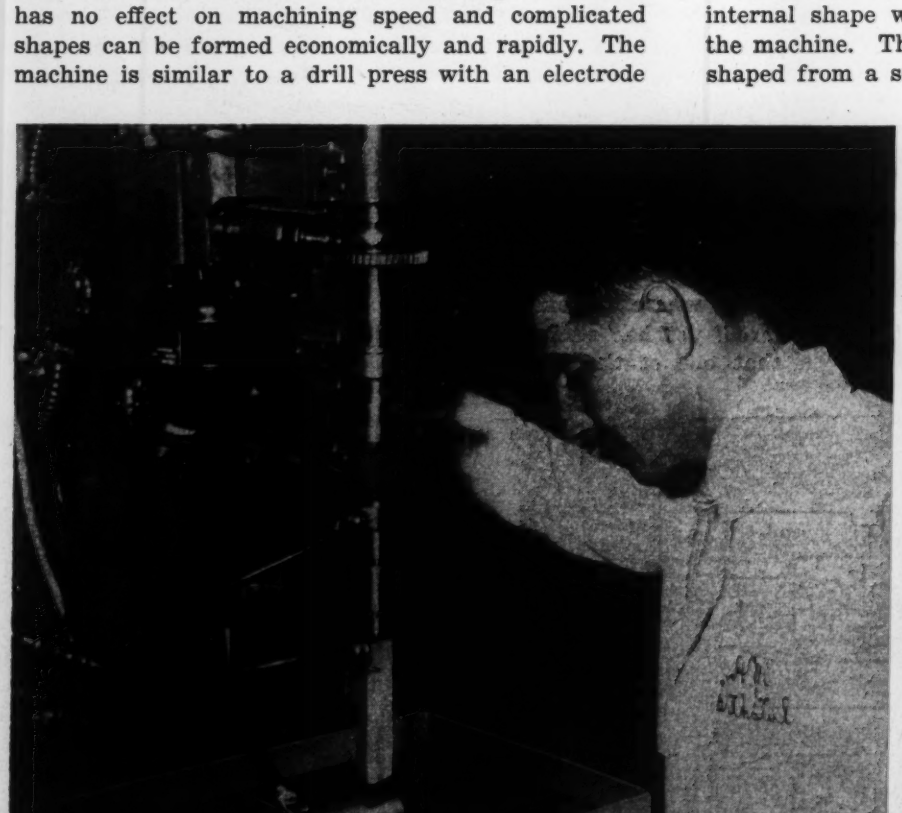
During assembly the inner cone is drawn axially into the V coupling, precompressing the rubber. With both the inner and outer sleeves rigidly joined, both layers of rubber actively transmit torque. Originally designed and patented by Metalastik Ltd. for application between the reverse-reduction gear of motor boats to provide torsional flexibility and to transfer thrust without excessive end float, the coupling has been employed successfully in locomotives, rotary-wing aircraft, and blowers.

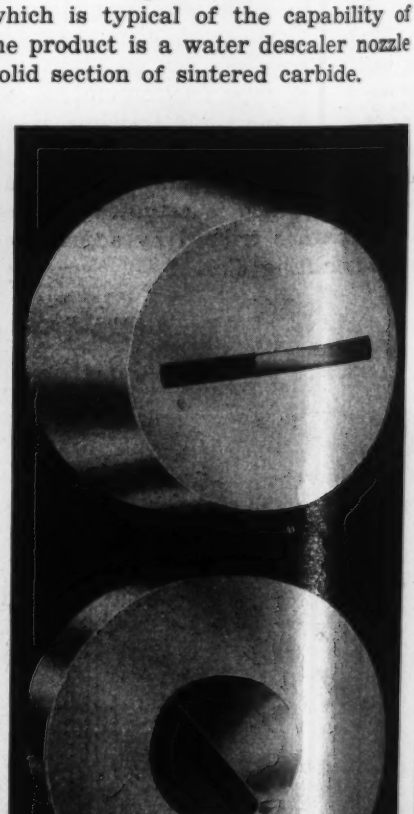
Hard-to-machine metals, such as sintered carbides and superalloys, can be machined economically and rapidly by a new method which employs the direct utilization of electrical energy. Known as the Method X and developed by the Method X Corp., an affiliate of Firth Sterling Steel & Carbide Corp., the process removes metal in a directed manner by an electric spark discharge which does not otherwise affect the physical or chemical characteristics of the work material.

The machining, below, sets up internal mechanical stresses by the use of extremely high current densities, causing the metal particles to detach themselves from the work without resort to melting. Hardness has no effect on machining speed and complicated shapes can be formed economically and rapidly. The machine is similar to a drill press with an electrode feed, control mechanism and a power supply. Feed is automatically controlled by an amplidyne and associated circuits. A dielectric fluid such as fuel oil or kerosene encloses the cutting operation to build up electrical resistance and to flush loosened particles.

Electrodes are highly conductive, easily machined materials such as brass. When the machining can be performed with the head moving in a vertical direction, the electrode is shaped to produce the form desired. When the work revolves or traverses, an electrode of brass wire, bent to the necessary working angle is all that is required since the tool does not make physical contact with the work.

Illustrated below is a compound radial-rectangular internal shape which is typical of the capability of the machine. The product is a water descaler nozzle shaped from a solid section of sintered carbide.





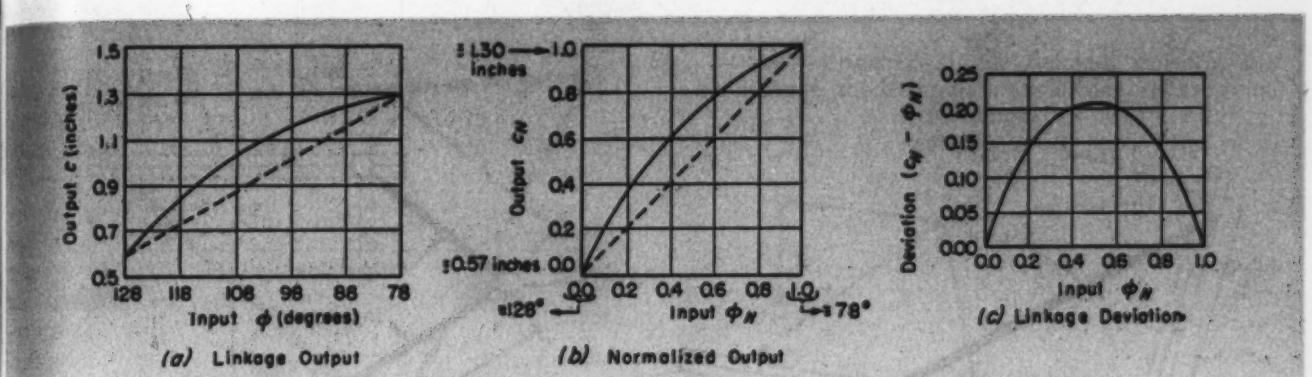


Fig. 1—Curves for a typical linkage showing *(a)* output plotted against input motions, *(b)* the normalized linkage trace wherein the motions are plotted as ratios of total motion, and *(c)* the deviation which is the difference between the trace and the straight diagonal line

Linkage Layout

How to match desired motions with suitable linkages. Five methods of layout are evaluated and the use of corrective cams for more precise results is explained

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BAR linkages, being commonly used in machine design to obtain intricately related motions, have caused each one of us to marvel at the ingenuity of some particular linkage design. It is just this factor of ingenuity, however, that has limited the use of linkages in machine design despite their simplicity, compactness and ease of fabrication on conventional machinery.

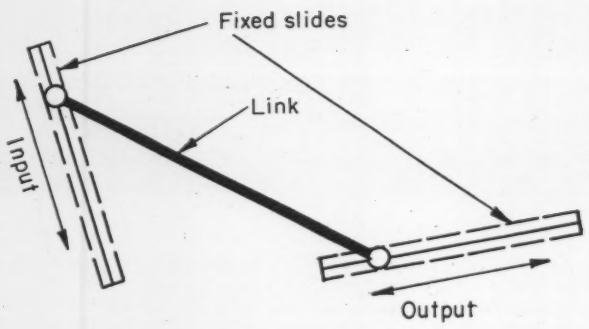
Many special linkages are discussed in texts on kinematics and mechanisms. This article, however, is concerned with those cases where the motion desired is not one for which known linkages exist. An exposition of systematic procedures for designing linkages, to reproduce arbitrarily prespecified relationships between motions, appeared recently in a book[1] on computers by Antonin Svoboda—one of a series of books devoted to radar systems.

This presentation is partly a digest of Svoboda's methods, in terms perhaps more familiar to the machine designer, with several essential differences based on the author's experience with the design of computing elements. In the computing-mechanism field, linkages enjoy a number of clear-cut advantages over cams and most of the same advantages should also apply to general machine construction: Friction forces are usually much lower, especially when a very "tight" (i.e., free from backlash) drive is required, and it is usually much easier to achieve high accelerations in the driven member. In addition, a linkage is often more compact, has only a small number of dimensions compared to the essentially infinite number of dimensions in a cam profile, and can be fabricated on simple standard machines. These advantages often are reflected in lowered costs.

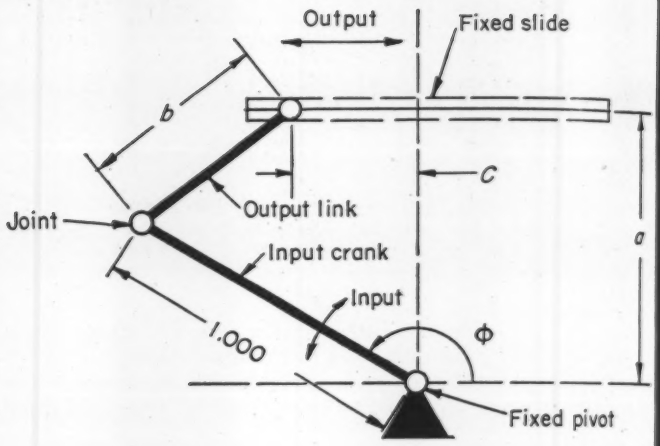
Before considering the methods for linkage layout, it will be helpful to establish a few conventions. The most important is that of "normalizing", that is.

Information in this article is based on work done under Air Forces Contract No. W 33-038 ac-20692.

[1] References are listed at end of article.



(*a*) One-bar linkage



(*b*) Harmonic Transformer HT

measuring the position of the input and output points, for any particular position of the linkage, in terms of fractions of their total ranges. For example, *Fig.* 1*a* shows graphically, for a particular arbitrary linkage, that as the angle ϕ of the input shaft turns from 128 degrees (from some arbitrary mark) to 78 degrees, the output member moves from a position $c = 0.57$-inch to a position $c = 1.30$ inches, in a manner related to the input motion and specified by the curve on the graph. For instance, when the input shaft is at 98 degrees, the output member is 1.15 inches from the mark. This same relation is plotted in *Fig.* 1*b* in terms of the normalized input angle $\phi_N = (128 - \phi)/(128 - 78)$, and the normalized output $c_N = (c - 0.57)/(1.30 - 0.57)$; the point ($\phi = 98$, $c = 1.15$) is now the point ($\phi_N = 0.60$, $c_N = 0.79$), and correspondingly for other points. The relation between input and output motion of a linkage, plotted on a unit square in terms of normalized inputs and outputs, is termed the "trace" of a linkage. The advantage of normalizing is that the traces of different linkages can be compared direct, whatever the input and output ranges or zero positions.

In layout work, the difference between the trace and a straight diagonal line (this latter, clearly, being the trace of a direct drive) is often more convenient to use than the trace itself. This difference is termed the "deviation" of the linkage; *Fig.* 1*c* illustrates the deviation of the trace plotted in *Fig.* 1*b*.

Although there are an almost infinite number of possible linkages, it has been found that three simple linkages, and their various combinations, provide adequate solutions to most of the problems that arise in practical work. These are the one-bar or "double-slide" linkage of *Fig.* 2*a*, the harmonic transformer or "crank and slide" *Fig.* 2*b* and the four-bar linkage, *Fig.* 2*c*.

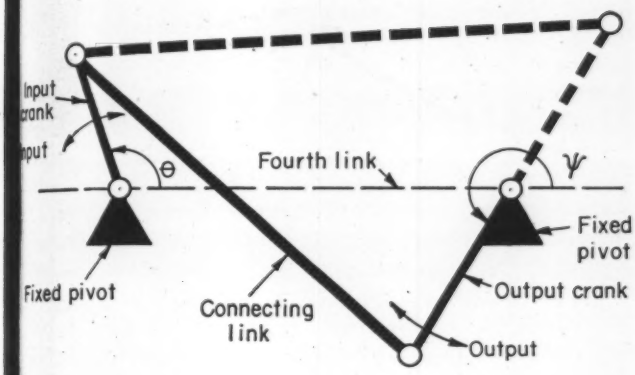
The trace of the double-slide linkage is a conic section; its deviation always resembles *Fig.* 1*c*, and it has no points of inflection. The amplitude of the deviation depends on the angle between the slides, and it can be made larger than the amplitudes for either of the other two standard linkages. This linkage is relatively little used, except as part of a linkage combination.

The harmonic transformer (hereinafter abbreviated as HT) can be used to convert oscillating rotary motion into a related linear reciprocating motion, or vice versa. It is perhaps the most flexible of the three standard linkages, reproducing a great variety of traces. While some HT's can be driven from a continuous rotary motion, the traces produced in this class of service are much less varied. An HT linkage, *Fig.* 2*b*, will reproduce curves like *Fig.* 1 if proper values of the linkage parameters are selected.

The four-bar linkage converts an oscillating or a continuous shaft rotation into an oscillating rotary motion. It has two distinct forms, for any one set of dimensions, as shown by the solid and broken lines of *Fig.* 2*c*. The variety of traces that this linkage will reproduce is astonishing, as a glance at the brief atlas of four-bar traces given by Svoboda[2] will confirm.

In practice, two or more of these standard linkages are often combined, one driving the next, to produce the desired final motion. Especially where the driving motion is the continuous rotation of a shaft, as is often the case in a machine, it is much simpler to obtain some given complex reciprocating motion by driving a four-bar linkage from the shaft rotation, and an HT from the oscillating output of the four-bar linkage, *Fig.* 3. If high accelerations are required over portions of the output motion, the HT may be followed by a double-slide linkage, or preceded by two four-bar linkages in series. Complicated relations between two reciprocating linear motions can sometimes be mechanized by two harmonic transformers back-to-back, as shown in *Fig.* 4.

It is rarely practical to design a linkage which represents the desired motion exactly. Where great precision is necessary, it is usually more practicable to use a small, low-accuracy cam with a lever system to make up the difference between the desired function and the linkage trace. *Fig.* 5 shows three such



(c) Four-bar linkage

Fig. 2—Left—Principal simple linkages showing the one-bar linkage, the harmonic transformer and the four-bar linkage

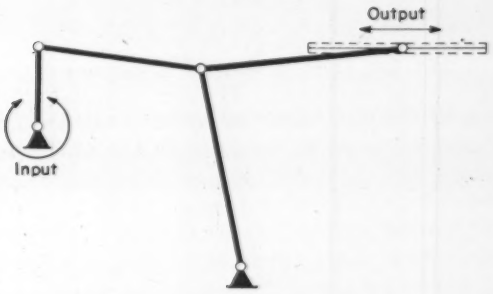


Fig. 3—Above—Four-bar linkage driving a harmonic transformer

Fig. 4—Below—Double harmonic transformer having translatory motions for both input and output members

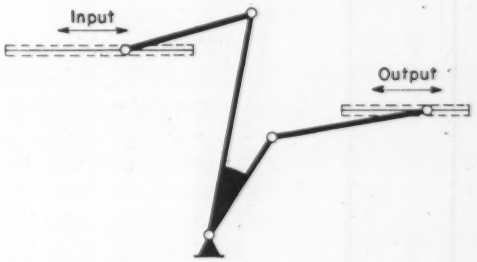
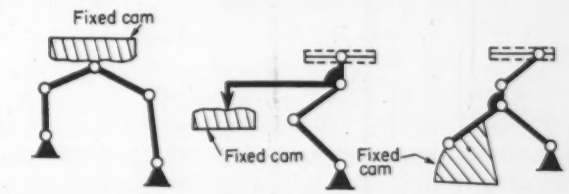


Fig. 5—Below—Linkage-cam combinations indicating how cams may be employed to correct output motions



(a) Broken Four-bar plus Cam (b) HT plus cam (c) HT plus Circular Cam

arrangements which combine compactness, simplicity of calculation, and insensitivity to small cam errors.

As an illustration, *Fig.* 6 is a detailed sketch of *Fig.* 5*c*. Suppose that the desired function is almost reproduced by the original HT, represented by *O-P-Q* in *Fig.* 6. If a rigid bell-crank, *P'-P-R,* rides on a truly circular cam *S,* of unit radius, around the point *O',* then *P'* is always a distance *c* above *P*. If the output slide is moved up parallel to itself by the same distance, the output at *Q'* is exactly the same as the output of the original HT. If, now, the cam profile *S* is distorted so as to raise *R* by a distance, *p,* perpendicular to the line *O-O',* then *P'* is moved nearly parallel to the output slide by an amount very closely equal to (p/n). The corrections to be applied to the original HT output are cut into the cam *S* at *n* times their actual value, and the precision required in cutting the cam profile is reduced by the same factor. Since *n* can easily be ten or twenty (if the cam correction is small), this permits a highly accurate mechanization without the cost of cutting a precise cam. Furthermore, since practically the whole throw is provided by the linkage, the cam radius can be small and the whole mechanism compact. Similar arguments apply to the units shown in *Figs.* 5*a* and 5*b,* and to many elaborations of them.

As a general prerequisite to successful linkage design, nothing can replace experience. Linkage design is still largely an art, an almost personal relation between the designer and his problem. Anyone designing linkages will soon develop a style of his own. For this reason, the methods which follow are points of view rather than rigid prescriptions. Five approaches are described; the first is of great assistance to the inexperienced designer; the other four are modifications of ideas given by Svoboda.

There is always some point (the point of diminishing returns) at which further adjustment of the linkage parameters is not worth while. At this point, a cam may be added to take out the remaining error, or the design may be accepted as adequate. No fixed rule can be set as to when this point is reached. Factors to be considered are the accuracy required, the shape of the motion being laid out, the number of machines to be built, etc. Associated with this is the problem of predicting, in advance, the difficulty which may be encountered in mechanizing a given motion. It is not clear what specific characteristics make a given function difficult to mechanize, although in general it is easier to mechanize a function having a smooth and reasonably symmetrical deviation-curve than one having a deviation-curve with irregular inflection points, or with a steep slope near one end. An experienced designer will often know by inspection whether he can design a simple linkage to mechanize a given deviation; an inexperienced designer may attempt several designs.

Given a specific trace to mechanize, the designer

may use a variety of methods. Our experience indicates that the following five are important. In general, the design methods to follow will be illustrated throughout in terms of HT's. However, the methods apply with little change to the design of other linkages.

Set of Traces Assists Designer

ATLAS METHOD: A set of curves (atlas) covering a fairly wide range of parameters for various types of linkages is invaluable to the beginning designer. It allows him to see at a glance those traces which he can reasonably expect to reproduce. It also allows rapid selection of a general region of parameter values where profitable use may be made of more exact linkage-fitting methods. For example, the traces of *Figs. 7a* and *7b* are two samples, copied from an atlas covering a wide range of HT parameter (a, b, ϕ_{max}, ϕ_{min}) values. The symbols used are defined in *Fig. 2b*. If the designer plots the given trace to the same scale as used in this atlas[3] (or in any HT atlas that he may have compiled), it may resemble one of them, or a section of one of them. From this resemblance an HT can be selected which approximates the desired trace.

Various reversals and mirror images of the linkage and trace are possible. For instance, if the given trace is like *Fig. 7c*, then proper reorientation (reversing) of *Fig. 7a* will demonstrate the identity of the two curves. The only difference in the required linkage is that its output c increases in the opposite direction from that originally indicated on *Fig. 7a*. It is also possible to change the sign of the input ϕ (inversion), or to reverse both c and ϕ together, so that any atlas which is compiled contains effectively four times as many traces as are evident at first glance. *Fig. 8* shows the corresponding four positions of an HT. For the particular atlas under discussion, interchange of input and output (reflection in a 45-degree axis) is not permissible, in general, since mechanical-lock positions may occur.

Sections of the complete traces may also approximate the given function. For example, the left-hand half of *Fig. 7b* closely resembles *Fig. 7d*. If the HT corresponding to *Fig. 7b* were operated over the range from 240 to 120 degrees, its trace would be a good approximation to the given function, *Fig. 7d*. It is often helpful to scale off and plot deviation curves corresponding to likely sections of atlas traces, for comparison with the deviations of desired functions. Usually a deviation curve which corresponds closely to the desired one can be found quickly. Since the atlas can be compiled in a definite sequence of parameter values, visual interpolation among adjacent traces often is possible.

A similar atlas of four-bar linkages might be compiled. Although a small atlas of four-bar linkages has been presented by Svoboda[2], it cannot be used in this manner. The recent atlas[4], by Hrones and Nelson, *Analysis of the Four-Bar Linkage*, is of some assistance in designing four-bar computing linkages but, in general, considerable conversion must be done to convert the graphs into proper form for such use.

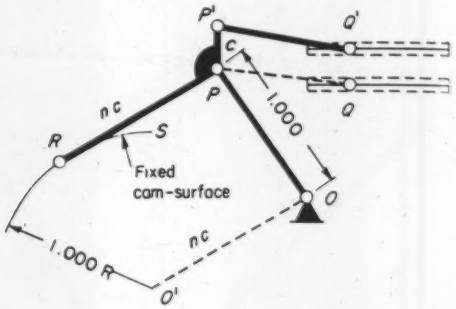


Fig. 6—Above—Harmonic transformer with correcting cam shown in *Fig. 5c*, illustrating how cam provides desired correction

Fig. 7—Below—Typical linkage traces showing how a given trace may match an inverted trace or a portion of a harmonic transformer trace

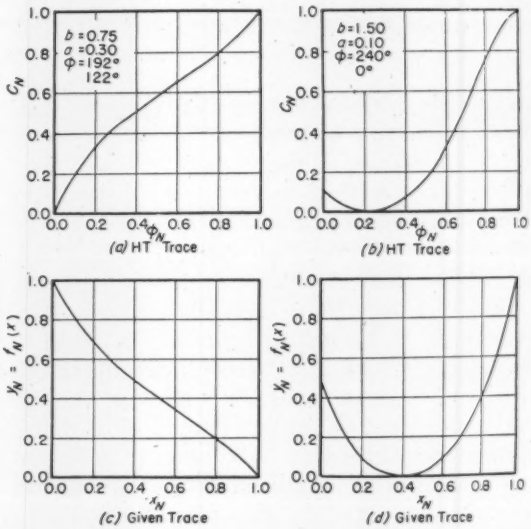
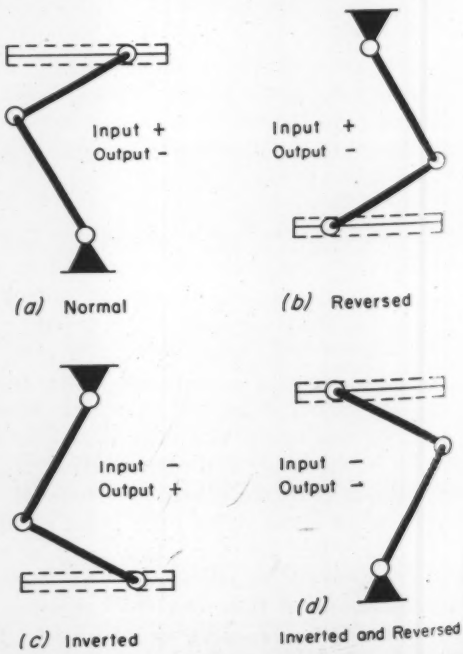


Fig. 8—Below—Inversion and reversal of a harmonic transformer to provide four traces



This would be expected because this four-bar atlas was not compiled for use in designing linkages such as those discussed in this article.

Linkages whose errors are less than two per cent (root mean square) of the total output range are readily selected from an atlas for many of the functions which are met in practice*. This is often not good enough, but the designer has at least located a general region (out of the whole gamut of parameter values) in which a possible linkage design lies, and he can proceed with one of the following methods if closer fit is desired. The first-selected region of parameter values may not allow fitting of the given trace closely enough; in this case the designer can usually find several other promising regions elsewhere in the atlas.

Use of one of the following four methods will usually fit a linkage to a desired motion within about 0.3 per cent (root mean square) error. Beyond this, the authors have found a correcting cam the most convenient solution, although Svoboda[5] recommends correction with eccentrics.

* In practice, an HT to represent an arbitrary motion can usually be designed with equal ease for any angular-input range between 50 and 120 degrees. Larger or smaller input ranges are less useful, in some cases, and may require gearing.

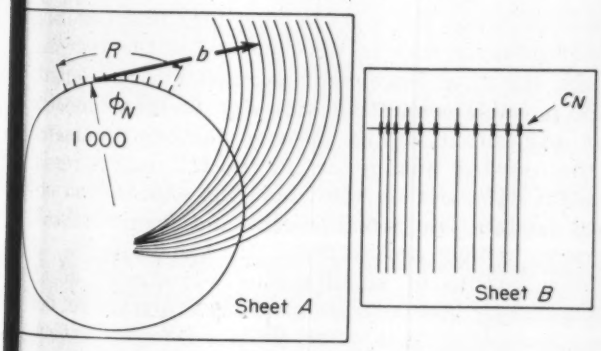
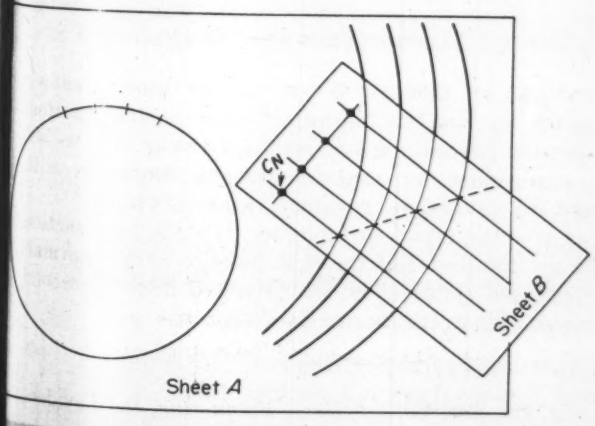


Fig. 9—Above—Overlay procedure in developing a linkage wherein Sheet *B* is laid over Sheet *A* as shown in *Fig.* 10

Fig. 10 — Below — Sample overlay with the dashed line indicating the intersections



OVERLAY METHOD: This method is graphical, and starts from estimated values of all but two of the linkage parameters. It indicates the best values for the two final parameters in terms of these estimates; it is therefore not exhaustive but is often rapid and effective. Svoboda has discussed[6] variations of this method, and its application to the four-bar linkage. The same method can be applied to HT's and to one-bar linkages.

Procedure: Assume a given function $f(\phi)$ to be approximated by an HT. Choose reasonable values for the output-link length b, and for the input range R, (i.e., $\phi_{max} - \phi_{min}$; see *Fig.* 2*b*), by reference to an atlas, for example. On a sheet of paper attached to a drawing board, *Fig.* 9, lay off a unit circle, and mark off on it, along the range R, the tabular values of the normalized input ϕ_N. From each marked point, swing a circle of radius b. This is Sheet *A*. On a second sheet, of tracing paper or transparent plastic, draw a straight line whose length corresponds to the shortest acceptable output range. Mark off along this line the corresponding (normalized) points $f_N(\phi_N)$, and draw a set of parallel lines, perpendicular to the output range, one through each marked point. This is Sheet *B*. Fig. 9 shows such a pair of sheets for this method of layout.

Now superpose Sheet *B* on Sheet *A*, and put a straightedge on top of Sheet *B*. Search for a relative position of Sheet *B*, Sheet *A* and the straightedge in which the intersections of the parallel lines with their corresponding circles all lie on the straightedge, *Fig.* 10. If such a position is found, mark the position of the straightedge with respect to Sheet *A*; an HT with input range R and output link b will lay off c_N along an output slide in this position. The dimension a, and the initial value of ϕ can be found by direct measurement on the marked Sheet *A*. Fig. 10 illustrates Sheet *B* superposed on Sheet *A*, with the dashed line indicating the line of intersections.

If no such line can be found, or if the line is found in a region where mechanical binding will occur, try different values of R, b or both if allowable. If the work has ben done carefully, the proper adjustment will probably be clear.

This method of design is especially valuable because, even if it is unsuccessful, it indicates to the designer what modifications are likely to work.

The designer will achieve accuracies to 0.3 per cent root mean square only if care and patience are used in drafting. Sharp pencils, large scales, and good beam-compasses are necessities. He should plan to spend several hours on each design in order to attain the limiting accuracy. A linkage designed by this method should always be calculated afterwards as a check, using Equation 1, or its equivalent for another linkage type.

Calculations Are Tedius

MULTIPLE-COMPUTATION METHOD: The most straightforward and probably the most laborious method of linkage design is direct computation. With the parameters exactly as indicated in *Fig.* 2*b*, the output c of an HT is:

$$c = \cos\phi + \sqrt{b^2 - (a - \sin\phi)^2} \quad \ldots\ldots (1)$$

By the use of computing forms, the normalized linkage output c_N can be calculated with reasonable labor, and compared with the desired function $f_N(\phi_N)$ for a number of sets of parameter values (ϕ_{max}, ϕ_{min}, a, b). If, for instance, a set of these values has been selected from an atlas, then eight additional sets can be made by increasing and decreasing each of these selected parameters separately by one per cent, say. By interpolating among the nine corresponding calculated values of c_N, an excellent second approximation to the best set of parameters can be chosen.

The disadvantage of this method, aside from the labor involved, is that it does not inform the designer quickly when no adequate HT exists in the region of parameters chosen. This same method can be applied to other linkages, such as the four-bar and the one-bar.

THE b^2 METHOD: This is another method[7] of direct computation; it requires less labor and informs the designer more directly of the exact situation. Instead of calculating the linkage output c_N from the input ϕ_N, a function of some other parameter, b^2 for example, is adjusted to fit the given input and output values ϕ_N and $f_N(\phi_N)$. The equations for b^2 are particularly simple; with the parameters as shown in *Fig.* 2*b* the equations are:

$$b^2 = (c - \cos\phi)^2 + (a - \sin\phi)^2 = a^2 + c^2 + 1 - 2c\cos\phi - 2a\sin\phi \quad \ldots\ldots (2a)$$

$$\phi = (R\phi_N + \phi_0) \quad \ldots\ldots (2b)$$

$$c = (Sc_N + c_0 = Sf(\phi_N) + c_0 \quad \ldots\ldots (2c)$$

The symbols, ϕ_N and c_N, denote the normalized input and output; R and S are the respective input and output ranges; ϕ_0 and c_0 are the respective zero points.

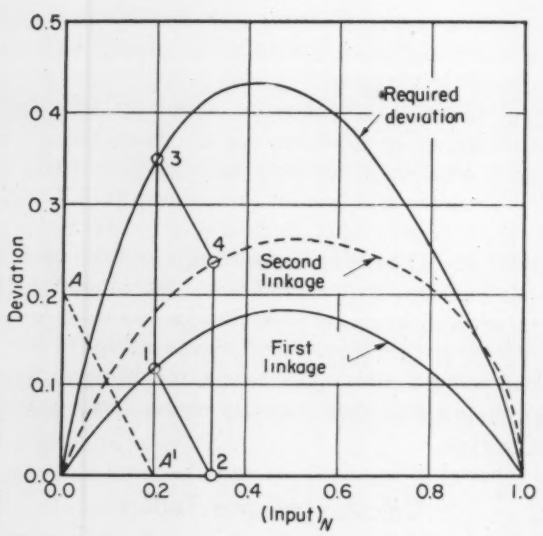


Fig. 11—Graphical deviation solution for combining two linkages to produce a desired motion

Hence b^2 is easily calculated from the parameters of an approximate fit. If the fit is exact, the calculated value of b^2 will be a constant, and when a fixed bar of length b is put in, an exact linkage will result. Usually, the calculated values of b^2 vary with ϕ_N; the designer's object is to adjust the various parameters in such a way that the value of b^2 is made as nearly constant as possible. The approximate effect of making various adjustments to the parameters can be calculated by expanding b^2 as a total differential:

$$d(b^2) = 2(a - \sin\phi)da + 2(c - \cos\phi)dc_0 + 2f(\phi_N)(c - \cos\phi)dS + 2(c\sin\phi - a\cos\phi)d\phi_0 + 2\phi_N(c\sin\phi - a\cos\phi)dR + \Delta(b^2) \quad \ldots\ldots (3)$$

Coefficients of the various parameter adjustments are themselves functions of ϕ_N, and by comparing them with the calculated b^2 it is sometimes possible to tell which parameter should be adjusted and how much. For instance, the coefficient of (da) in Equation 3 is $2(a - \sin\phi)$; if the b^2 curve is similar to a plot of the coefficient of da, then adjustment of a will correct it, at least partly. Usually it is only necessary to plot the coefficient of Equation 3 and compare them visually to b^2 as given by Equation 2, to determine the required adjustments. Equation 3 is a linear first approximation only; it is misleading unless the approximate linkage-parameters give a reasonably close reproduction of the desired function.

Corresponding expressions for the four-bar and one-bar linkages may be developed. For the four-bar linkage, the most convenient parameter is the length of the movable connecting link, *Fig.* 2*c* that connects input and output cranks. Use of another parameter for the four-bar linkage, or for the HT, might result in useful data, but on the whole the expressions obtained contain fractional powers and long algebraic fractions, which are difficult to handle.

The possiblity of simultaneous adjustment of all parameters by least-squares methods is attractive, but rarely successful. It is worth while, however, to calculate the coefficient functions of the various parameters in Equation 3 since improvements by adjustment of one or two parameters may occur and, in addition, the designer will be much better informed as to the problem confronting him. A b^2-curve resembling two cycles of a sine curve indicates that further improvement is unlikely.

Linkage Combinations May Be Desirable

LINKAGE IN SERIES: When two or more linkages in series are used to represent some desired motion, the layout procedures are still relatively simple, but real care must be used to prevent confusion with regard to inversion, reversal, ranges, etc.

Let x be the input variable and $f(x)$ be the function to be mechanized. Let the first linkage have a normalized output, $g_N(x) = y$, which is fed into the second linkage, giving the normalized output,

$$h_N(y) = h_N[g_N(x)] = f_N(x) \quad \ldots\ldots (4)$$

that is, the desired function. From this, it is evident

(*Concluded on Page* 194)

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HOW TESTS CAN IMPROVE *Selection of Engineers*

MANY employers feel that a good engineer can usually be spotted in an interview. They consider the information and impressions thus gained to be the best indication of a man's potential worth to an organization. Other employers rely heavily on college transcripts, recommendations from college professors, and other personal references. Some attach considerable significance to an applicant's previous work experience, and still others depend on the findings of personnel tests. There are many selection factors which can be considered in a final choice and probably as many conflicting views as to their relative value. However, the advantages and limitations of most of the various nontest selection practices are probably better known to engineering administrators than is similar information about personnel tests. It is, therefore, with the use of tests for selecting technical personnel that this article will primarily be concerned.

Actually, some companies have little or no need for personnel tests in their selection program. Just as a new mechanical undertaking must usually be analyzed to determine if specialized tools and equipment are needed, so does the need for tests depend upon the specific selection situation. The decision to explore the possibilities of any new selection proce-

The complex and urgent nature of engineering assignments today demands the selection of truly competent personnel and their most effective utilization, in the face of a limited manpower supply. How the first step—selection—can be improved by the scientific application of personnel tests is discussed in this article. It gives insight into a subject which is often misunderstood, and suggests a program for joint action by engineering management and the personnel department

dure—or even to alter an existing practice—should be based only on the findings from a systematic appraisal of an organization's personnel program. If such a study shows a need for more effective personnel selection, there is then justification for considering some revision of the selection program.

If an organization decides to introduce tests in an attempt to improve personnel selection, the question arises: just what is the best way to go about installing a testing program? This question in itself is somewhat controversial. It is a point on which even psychologists disagree to some extent, dividing themselves roughly into two camps.

On one side of the fence are those who favor what might be called the "apparent validity" approach. Its practitioners believe that they can rather directly select tests which will identify those applicants who possess the abilities and traits necessary for good job performance. Their choice is based on close observance of the job, a careful and detailed study of the job analysis, and reliance on their specialized knowledge and experience. The proponents of this approach usually do not conduct any further investigation to uncover *proof* of whether, or how much, the chosen tests actually do differentiate between effective and ineffective employees. Because they choose their tests largely on the basis of "professional insight," the client organization must necessarily place a great deal of confidence in the judgment of the individual developing the test program. A number of organizations have, however, reported success with this apparent validity approach, though in many instances the evidence of this "success" is more subjective than objective.

Tests Should Be Proven

The alternate approach to the installation of a testing program might be called that of "demonstrated validity." Its advocates hold that, although a test may originally be given consideration because it seems to be applicable, it should always *prove* its ability to differentiate effective from ineffective personnel before being accepted as a selection tool. In other words, they believe in "testing the tests"—in proving, or disproving, a theory before actually applying it.

This process of actually demonstrating a test's validity naturally involves more labor, time, and expense than simply adopting a test on its face or apparent value. But just as with research in other areas, the additional effort may often be rewarded by more meaningful results. Many companies have reported improved personnel selection with tests chosen by this demonstrated validity approach. Perhaps a short description of a study conducted along these lines at the Hamilton Watch Co. might serve as an example to illustrate the general procedure.

Two tests were used in this study: the Stanford Scientific Aptitude Test, developed to measure, in the words of its author, "basic traits which enter into what may be called aptitude for science or engineering;" and the Wonderlic Personnel Test, a short, timed test measuring what is usually termed "general intelligence." These two tests were given to all applicants for mechanical engineering and similar technical positions. However, scores on these tests were not considered in selecting new personnel; hiring was done on just the same basis as before the experimental work with the tests was begun. After sufficient time had elapsed to enable these new men to demonstrate their on-the-job performance, their technical competency was rated by their supervisors with one of the procedures developed for this purpose. These performance ratings were then compared, by means of an accepted statistical technique, with scores made on the two tests administered at the time of their employment.

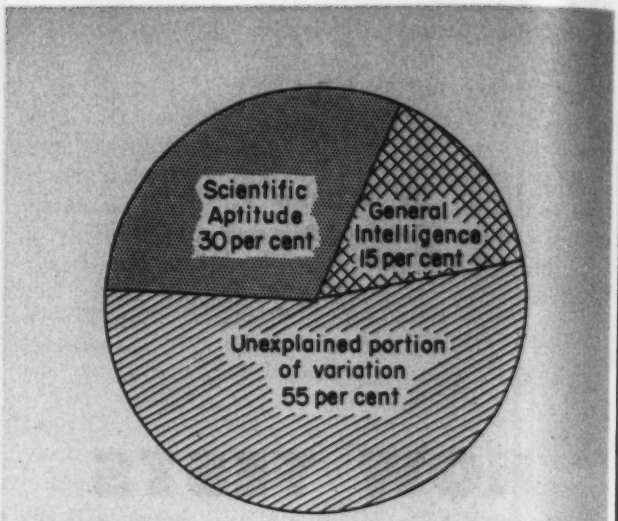

Fig. 1—Circle represents "total variation" in engineering performance. In the Hamilton study, general intelligence and scientific aptitude accounted for 45 per cent of the variation. Testing for these qualities improved personnel selection approximately 26 per cent over chance

The results revealed that the Stanford Scientific Aptitude Test differentiated between high-rated and low-rated men to a marked degree, and the Wonderlic Personnel Test to a satisfactory but somewhat lesser degree. The two tests in combination, however, showed a better differentiation than either test alone. The individual contributions of these two tests in accounting for the differences or variation in the job performance of mechanical engineers at the Hamilton Watch Co. can be seen in *Fig.* 1. The circle in the figure represents "total variation" in engineering performance. Scientific aptitude constituted approximately 30 per cent of this variability with general intelligence being responsible for approximately 15 per cent. Knowledge of what constituted even this much—45 per cent—of the variation in engineering performance indicated the possibility of selecting "successful" engineers (those rated above average in job performance) some 26 per cent better than selection by chance. Such an improvement was considered quite valuable, particularly when applied on a group basis.

This relationship existing between test scores and ratings on technical performance does not, however,

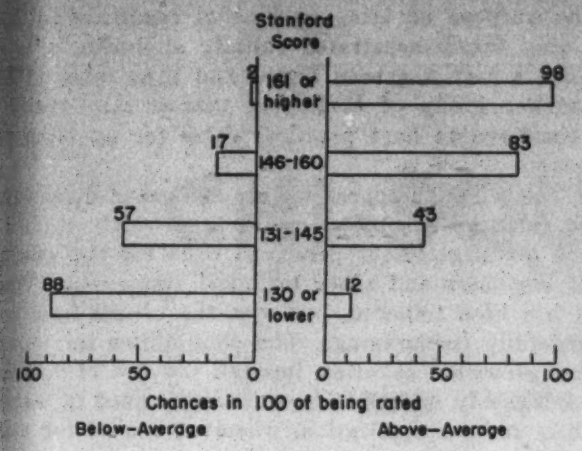

Fig. 2—This expectancy chart shows a Hamilton engineer's chances in 100 of being rated above-average or below-average in technical performance according to his score on the Stanford Scientific Aptitude Test

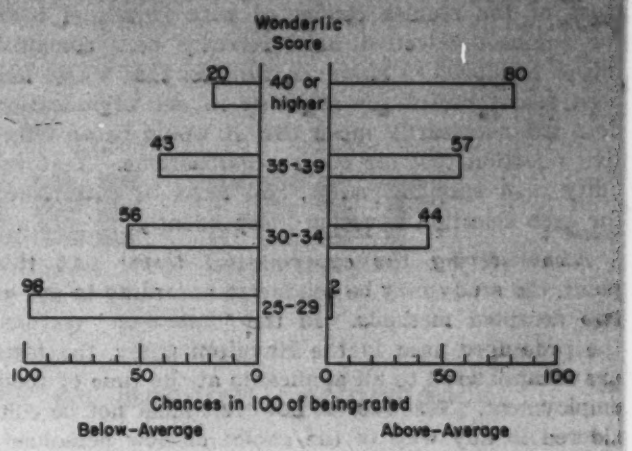

Fig. 3—This expectancy chart shows a Hamilton engineer's chances in 100 of being rated above-average or below-average in technical performance according to his score on the Wonderlic Personnel (intelligence) Test

provide absolute prediction of a given engineer's success on the job. A sizable share of the variation in engineering performance is still left unaccounted for, and this unexplained portion naturally introduces an element of predictive error. For example, there is always the possibility that an engineer applicant who scores high on the Wonderlic and Stanford tests might prove to be ineffective because of the influence of significant factors involved in the unexplained portion of variation in engineering performance. For the same reason, there is also the possibility that another engineer applicant might display quite acceptable job performance even though his test scores were comparatively low. Such exceptions to this general relationship between test scores and rated technical performance will naturally occur and must therefore be expected. Scores achieved on the Wonderlic and Stanford tests predict only an engineer's *chances* of job success, as illustrated by the expectancy charts in *Figs.* 2 and 3. It should be emphasized that the two tests which were found to have predictive efficiency in the Hamilton study would not necessarily be valid for selecting engineers in other companies and industries.

The Hamilton study is not an isolated instance of the demonstrated validity approach; similar work has been done by other organizations. The Detroit Edison Co., for example, used this approach in developing a test battery for the selection of electrical, mechanical, and chemical engineers, as well as for mathematicians and physicists. Swartz and Schwab, who conducted this research, report[1] that standards established on the Minnesota Paper Form Board and on three sections of the Michigan Vocabulary Profile Test were quite effective for selecting research engineers who rated above-average in job performance.

Mandell[2] has conducted similar studies for the U. S. Civil Service Commission, using groups of electrical, aeronautical, mechanical, and radio engineers. He reports significant findings with a mathematical formulation test, a measure of spatial visualization, an evaluation of hypotheses test, a table reading test, and an achievement examination in physics. In addition to the test findings he also discovered that certain biographical variables, such as "age at graduation from high school" and "participation in athletics," were related to various aspects of technical performance.

Systematic Procedure Required

"Testing the tests" is something that must, of course, be done by means of a systematic analysis, and scientific methods of measuring test validity have been developed. An undertaking of this type necessarily demands the services of personnel with specialized training—just as an appendectomy demands the skill of a surgeon even though the patient is familiar with the general procedure. However, the steps outlined below are, in a broad and general way, those that would probably be followed should such a study be conducted under competent direction.

Analysis of the job: A detailed description is prepared of the job and its requirements, and other factors inherent to the job setting are carefully studied. The information gained from this analysis will then be used as a basis for selecting experimental tests and for developing measures of job performance.

Selection of experimental tests: Tests which appear applicable are now selected for use on an experimental basis. These tests should show an acceptably high degree of reliability—that is, they should be reasonably consistent in their measurement.

One source of suggestions as to appropriate tests

[1] References are tabulated at end of article.

for experimental use is the published literature describing employee selection studies. Abstracts of most of the studies conducted with personnel tests for engineer selection have recently been compiled into a handbook.[3] However, the fact that a test has been found useful for selection in one organization does not necessarily mean that it would be an effective selection tool for other organizations. Test validity is a specific quality, and must be determined for each selection situation independently.

Administering the experimental tests: At this point, the study may be conducted according to one of two accepted methods. In the "follow-up" method, the procedure used in the Hamilton study, the tests are administered to all applicants at the time of their employment. Test scores, however, must not be considered in any way in the choice of new personnel; selection must be made just as if no tests had been given. Then, after enough time has elapsed to enable these new employees to demonstrate their ability and competence, test scores are compared with their on-the-job performance.

In the "present-employee" method, the experimental tests are administered to the *existing* personnel, and test scores are then compared to their present job performance.

There are advantages and disadvantages to both methods. The present-employee method is without question a time-saving one, but there is always some doubt as to how much the test scores may have been affected by on-the-job experience, and as to how much selectivity is involved among the subjects. Although the follow-up method eliminates this problem, it obviously requires a much longer time for the completion of the study. Statistical techniques are available, however, to diminish some of these disadvantages.

Developing a criterion of job performance: Probably the most critical aspect of any research of this sort is that of acquiring a trustworthy yardstick, or criterion, against which to measure the value of the experimental test or tests under consideration. It must be determined, with as much accuracy as possible, just which men are outstandingly effective, which are mediocre, and which are relatively ineffective in job performance, and how much so. A number of procedures[4, 5, 6] are now available for developing such performance criteria and most of them can be depended upon to yield reliable results when properly used.

Determining the value of the tests: There are a number of analytical methods by which a test's effectiveness as a predictive device can be determined. Some of the more commonly employed methods have been described by Adkins[7] and by Doppelt and Seashore.[8] These procedures vary from the rather elementary and cursory methods to those which are considerably more accurate and refined but more involved. The use of these techniques naturally requires specialized training in the theory and application of psychological statistics.

Retesting the tests: This step is known as "cross-validation," and is taken merely as a precaution. Chance errors involved in the original data may occasionally lead to spurious or false impressions about a test's worth; the double-checking operation is for the purpose of bringing such a condition to light. Under the demonstrated validity approach, it is not until a test has been tested and then retested with another group of employees that it may really be considered to have practical value for selection purposes.

The scientific approach—the method of demonstrated validity—has by no means been widely applied to the investigation of personnel tests for the selection of engineers and other technical employees. Where it has been followed, however, the results have been generally encouraging. The possibilities for improving personnel selection through the use of "proven" tests surely appear to be sufficiently good to warrant their further application, wherever a need for better selection exists.

One final word, however, is in order. It is not to be inferred that personnel tests—regardless of their effectiveness—can select engineers independently of other considerations. Final selection should never, under any circumstances, be made on test results alone. The pre-employment interview, and personal, educational and occupational data, as well as other nontest information, are potentially significant selection factors. Results of validated tests must be considered in conjunction with all these, as part of the total selection procedure.

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They Say...

"You can't fight a modern war or maintain a modern peace without highly trained manpower. You can't do either without first-rate scientists or engineers."—DR. JAMES R. KILLIAN, JR., *president, Massachusetts Institute of Technology.*

"Plans for industrial mobilization in case of war incorporate producibility as one of the key factors. Producibility has been placed on a level with tactical suitability and engineering in plans for equipping the Air Force with adequate planes in case of war and is considered a major item in the evaluation of new aircraft designs"—MAJOR GENERAL F. M. HOPKINS, JR., *USAF, chief of the industrial planning division, Air Materiel Command, Wright Field.*

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CHI-SQUARE TEST

. . . gives simple check on machine performance

By Wayne A. Ring
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and

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WHEN the performance of a newly designed machine is compared with that of existing machines, the comparison is often subjective or consists of a simple division problem from which the statement is made that the new machine is, for example, 10 per cent better than the existing one. A valid question should be raised, however, and this is—was the test performance actually representative of the new machine or was the sample test, by chance, an unusually good performance which occurs occasionally through normal variations of performance?

From a study of the laws of probability, statisticians have devised a test for comparing sets of data which helps answer this question. For want of a better name, Chi-Square was used to denote the calculated number upon which the comparison test is based. The combination of two formidable topics, Greek and Mathematics, into a single symbol has frightened many away from the Chi-Square technique when in reality the arithmetic is simple and the conclusions are easily drawn. The nomogram presented here further simplifies the Chi-Square test.

In using the Chi-Square test there are always two sets of data: the *actual data* consisting of observed numbers from inspection of machine performance; and the *expected data* which is obtained by calculation, specification, or past performance records. The *actual* numbers are compared with the *expected* numbers by: (1) Subtracting, (2) squaring the difference, (3) dividing the square by the expected numbers, and (4) adding up these quotients for each pair of numbers.

These four steps are all the arithmetic that the test involves—subtract, square, divide, and add. The result of this arithmetic is the number called Chi-Square. From the table of data, a number called the *degree of freedom* for the test is then determined. This number equals the number of classes of data minus the number of constants in which the actual and expected data were made to agree. Having determined the Chi-Square and degrees of freedom, the nomogram in *Fig.* 1 can be used by joining these numbers on their respective scales with a straight line. This determines P, the probability that the *expected* performance would yield an *actual* sample of no better agreement. Statisticians generally accept a value of P less than 0.05* as an indication that the expected and actual numbers come from different distributions. The lower the value of P the more certain one can be that the new machine is performing fundamentally different from the old machine. A value of P higher than 0.05 indicates that the difference in performance of the new and old machines might be due to chance. Thus, use of the Chi-Square test enables one to determine if valid comparisons can be made between expected and actual data. Too, it can be used with any type distribution, the only restriction being that the *expected* numbers should

* Croxton & Cowden—*Applied General Statistics*, Prentice-Hall Publishing Co., Page 287.

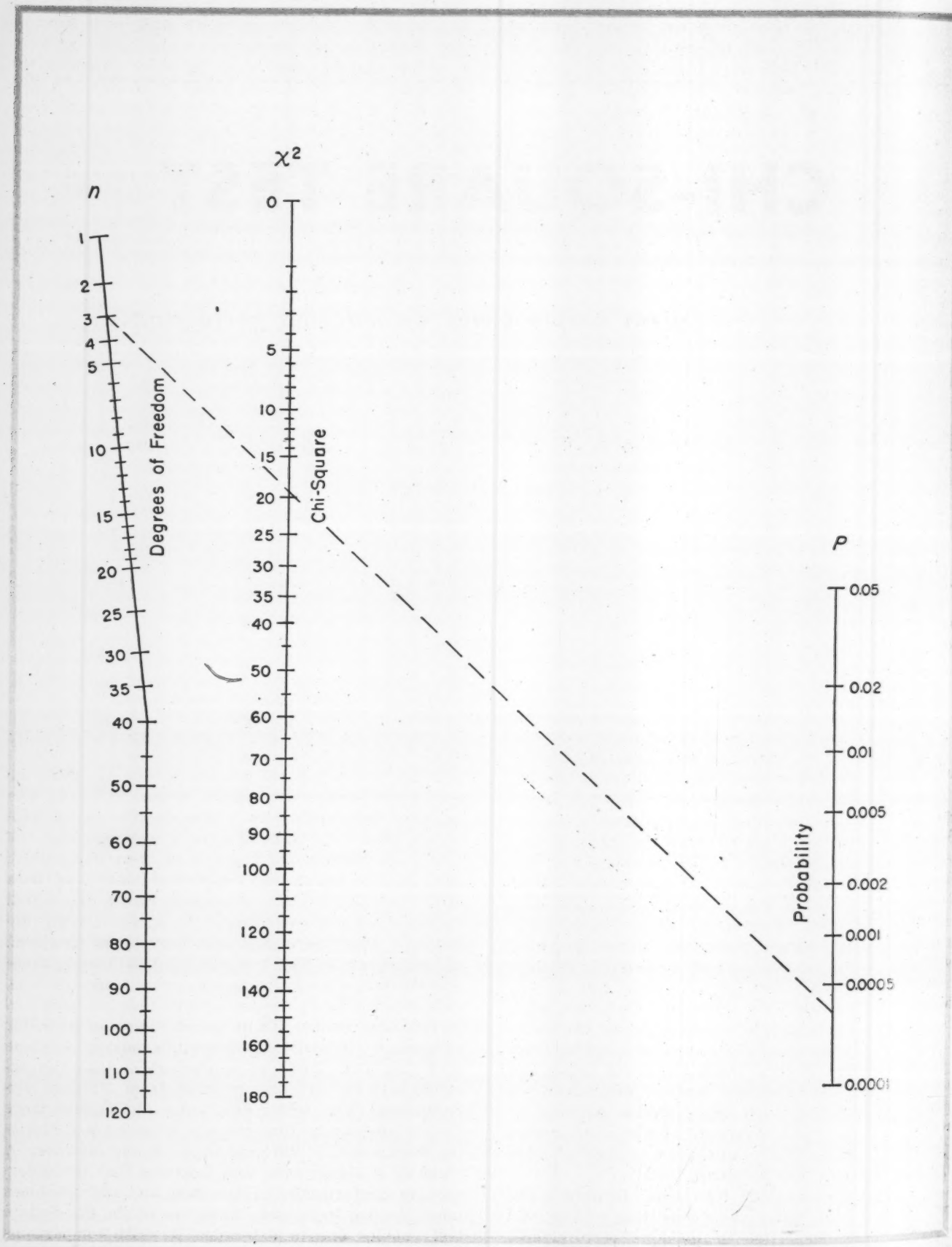


Fig. 1—Nomogram for Chi-Square test designed to determine the probability P from square of x and degrees of freedom n

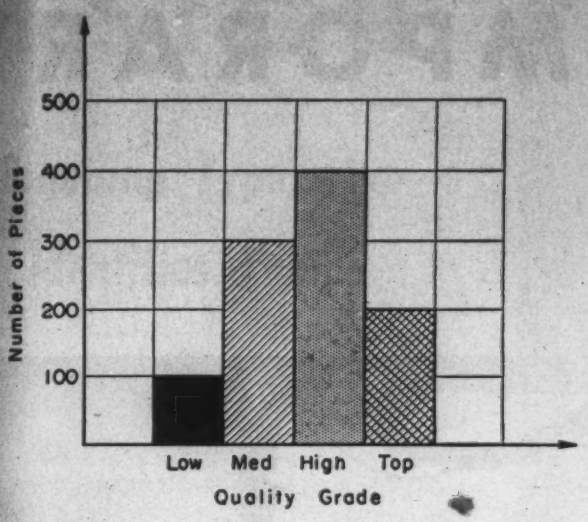


Fig. 2—Expected output of 100 pieces based on past performance record of present machine

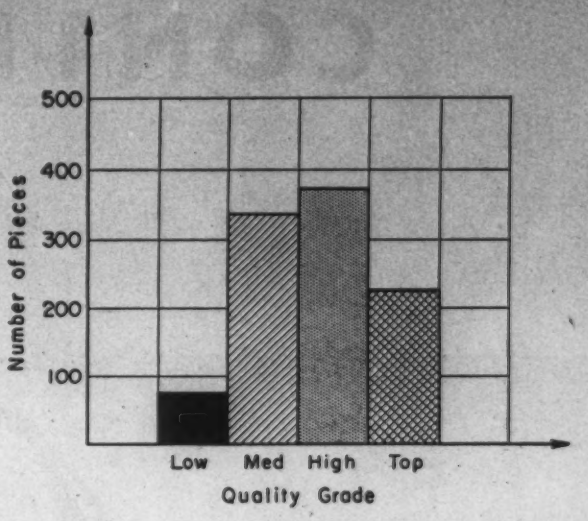


Fig. 3—Actual output distribution record of 1000 pieces produced on the newly designed machine for performing the same job

not be less than 5 in value.

As an example, consider a machine whose past record indicates that an output of 1000 pieces would be graded as follows:

EXPECTED OUTPUT:

Top grade	200
High grade	400
Medium grade	300
Low grade	100

and would appear in distribution as shown in Fig. 2.

A new machine, designed and built to do the same job, turns out 1000 pieces graded somewhat differently as follows:

ACTUAL OUTPUT:

Top grade	227
High grade	376
Medium grade	330
Low grade	67

with the distribution shown in *Fig.* 3.

The question is whether the actual figures are fundamentally different from the expected figures or whether the difference is due to chance. The Chi-Square test can answer this question by calculations indicated in TABLE 1.

Table 1—Chi-Square Test Calculations

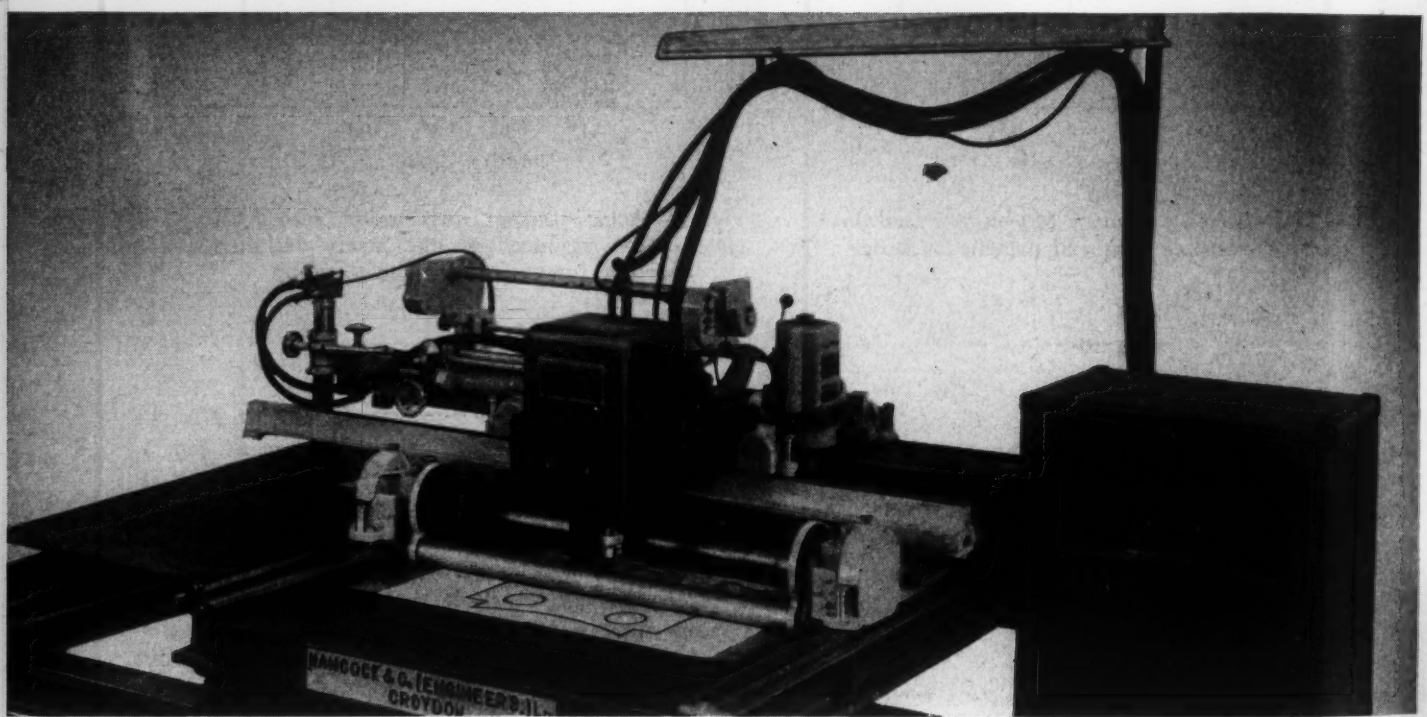
Grade	Expected	Actual	Difference	$\frac{(\text{Difference})^2}{\text{Expected}}$
Top	200	227	27	3.645
High	400	376	24	1.440
Medium	300	330	30	3.000
Low	100	67	33	10.890
Total	1000	1000		18.975

The number of degrees freedom is 3 because we have four categories and have adjusted both totals to 1000. With the two numbers, 3 and 18.975, we draw a line on the Chi-Square nomogram of *Fig.* 1. This line falls below the 0.0005 mark on the *P* (Probability) scale which indicates the chances are extremely small that the actual data was a sample from the same distribution as that of the expected data. Therefore, we can conclude that new machine is performing fundamentally different from the old machine and have more assurance that comparisons made are valid.

Boiler is World's Largest

THE WORLD'S largest reheat boiler to generate steam has been purchased by Consolidated Edison Co. from the Babcock & Wilcox Co. The new boiler will be as high as a 14-story building and will produce 1,200,000 pounds of steam per hour—sufficient to generate electricity for a city of 400,000 people. Built in sections, it will be assembled at the site like a prefabricated skyscraper. The boiler will initially burn oil, with provision for future installation of coal burning equipment and will develop steam temperatures of 1000 F. Water is heated while circulating through nearly 65 miles of tubes varying from two to five inches in diameter. Designed to burn about 10,000 gallons of oil per hour, enough to heat an average five-room home for 10 years, the new installation differs from the conventional boiler in that the steam at 1000 F drives a turbine and then, when the steam temperature has dropped to 650 degrees but before condensation, it is returned to the boiler to be reheated and used to drive a second turbine. The efficiencies of this system will reduce the fuel bill five per cent under that of conventional systems.

CONTEMPORARY



Electronic Head Guides Flame Cutting Machine

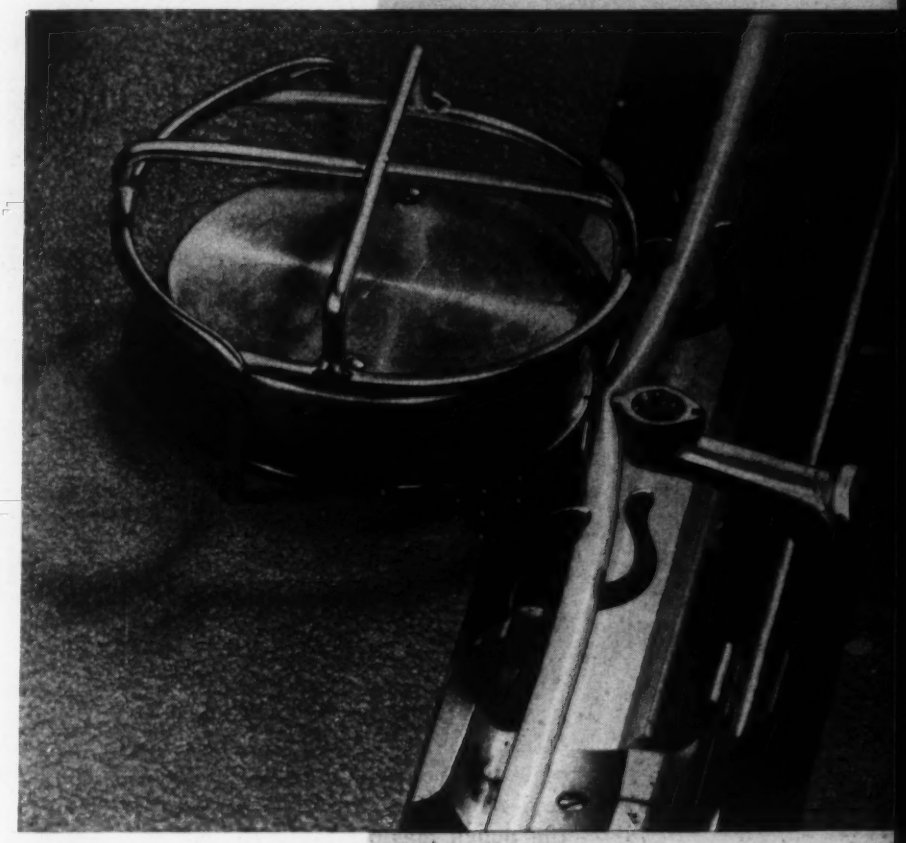
UTILIZING an outline drawing as a template, a phototube control accurately positions the torch in the Hancock & Co. Ltd. machine, above, to produce a flame-cut part having the exact size and shape of the drawing. As seen in the illustration, the torch and electronic sensing head are attached to the transverse upper carriage so that the position of the torch always corresponds to that of the electronic unit, offset a fixed distance. A tracer wheel on the electronic head, instead of engaging the drawing table, is in pressure contact with the top of a cylinder mounted on the main lower carriage parallel to the supporting wheels. This cylinder runs the length of the carriage and is geared to a pair of supporting wheels so that when rotated the peripheral speed of the cylinder corresponds to the speed of the lower carriage in relation to the drawing table.

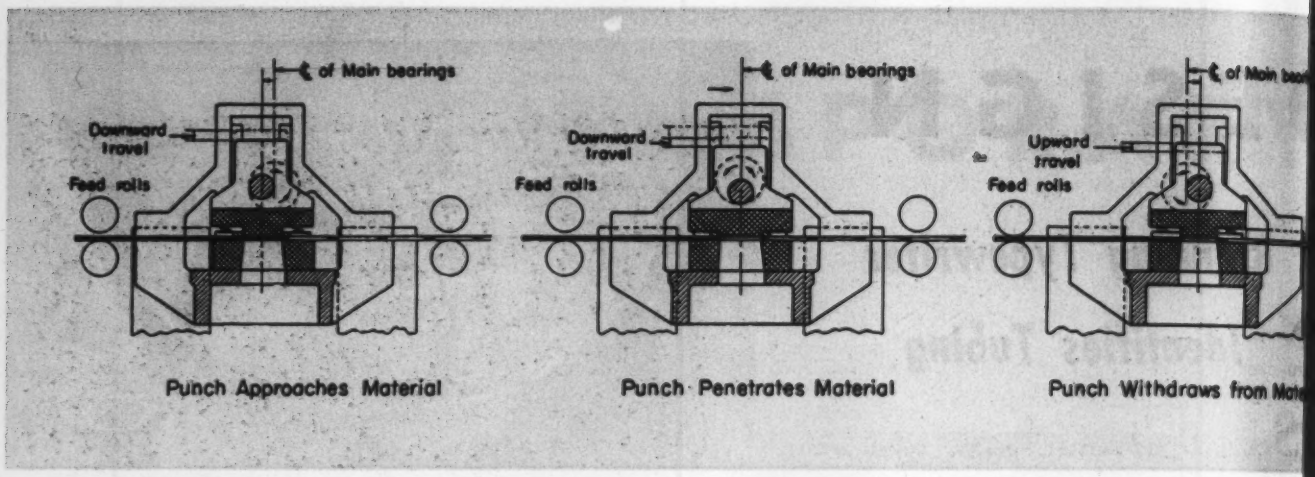
When the axis of the tracer wheel is parallel to that of the cylinder, the wheel causes the cylinder to rotate and the lower carriage travels as if the wheel were in contact with the paper. When the wheel is perpendicular, the traverse carriage moves similarly. In all other positions, movement is a combination of the two. Two motors are contained in the tracer head, one to rotate the tracer wheel and one to steer the vertical spindle of the tracer wheel drive. A small spot of projected light is kept, by the phototube control, so that it is half on the ¼-inch drawing line and half off. Any deviation results in adjustment of the variable-speed steering motor to correct the position. Speed of the tracer wheel is controlled so that, even at acute corners, the path of the drawing will be followed. In this way the drawing outline is accurately translated to the steel plate being cut.

DESIGN

Branding Typewriter Identifies Tubing

SPECIAL typewriter, below, developed by Ralph C. Coxhead Corp. identifies wire terminals in electrical systems. Vinylite tubing, such as used in wiring, is clamped in position in the machine so that identification or coding may be typed direct on the tube. The close-up view, right, shows an electrically controlled hammer forcing the tubing against a character on the type font. This font is electrically heated so that, when the hammer impresses the tubing against a thin carbon ribbon and the type, an indelible impression is made on the tubing. The type fonts may be changed so that proper size characters may be impressed on tubing ranging in size from ⅛ to ½-inch diameter.

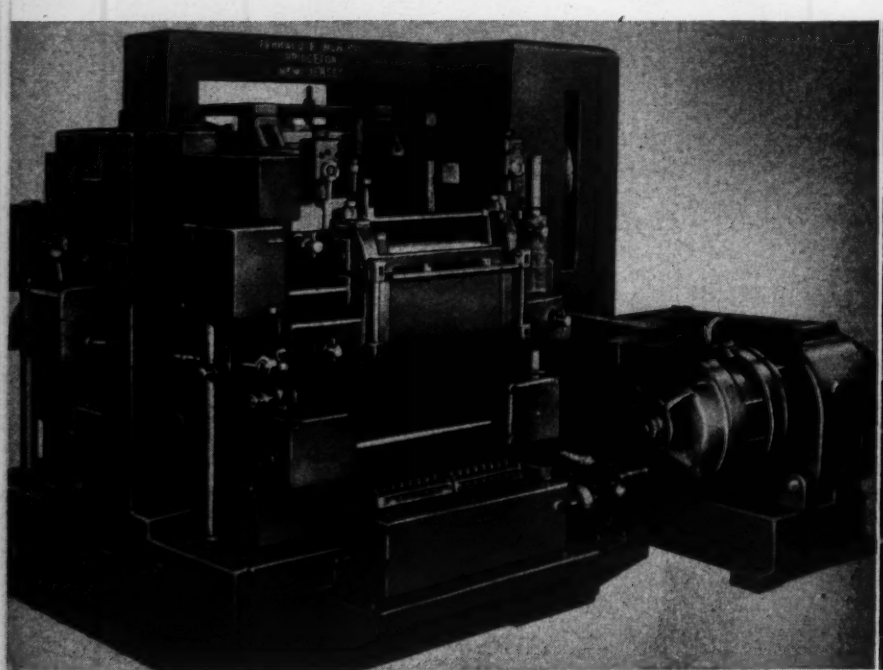


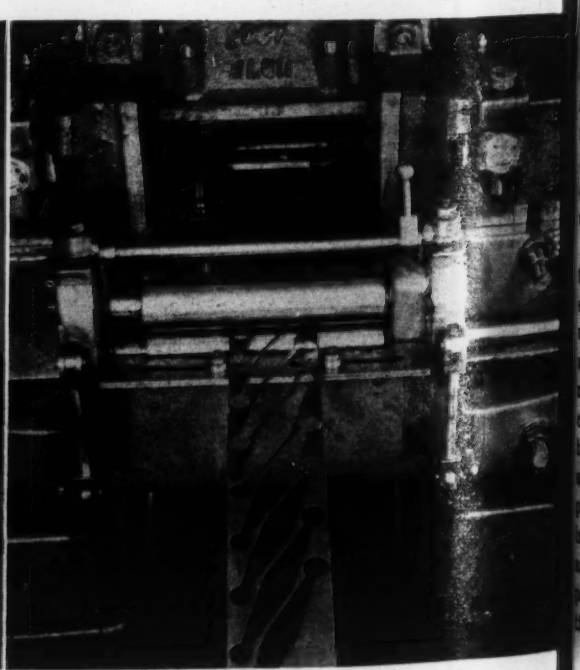


Punch Press Moves Strip Continuously

ELIMINATION of lost motion in the punch press illustrated below makes possible the production of 1000 blanks a minute. This is accomplished by reciprocating the die bed to obviate the intermittent feed motion of the stock. Amount of bed travel in this press, designed by Ferracute Machine Co., is adjustable to feed requirements. As shown in the drawings of the cycle of operation, above, the punch member takes its motion direct from the crankshaft, the amount of stroke also being adjustable. This rotary motion of the punch face coincides at its lower arc with the reciprocating die on its foward stroke. Gripped by the stripper, the material is held between the punch and die, both members traveling forward horizontally as the punch penetrates the work, passes the center point and withdraws from the work, the stripper clearing the punch.

Material is fed forward by feed rolls driven from the crankshaft. Feed roll speed is controlled through a variable-speed drive which may be adjusted while the machine is running to synchronize the feed of the material. Cam-operated feed-roll lifters release the rolls while the stripper is in contact with the material and while piloting and forming are being done.





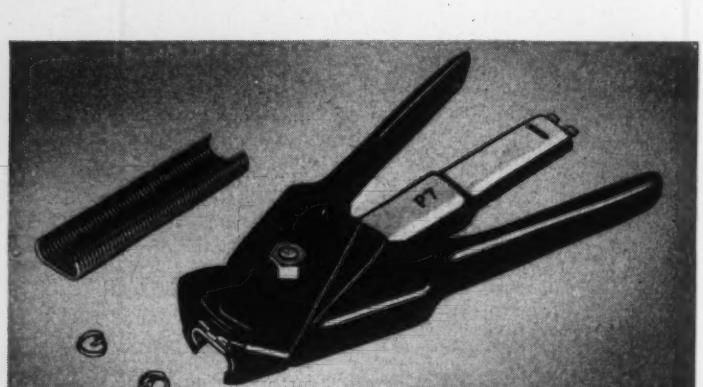
Open-Handle Iron Reduces Fatigue

NEW styling of the traditional hand iron reduces the physical strain of ironing by permitting the wrist and hand to remain in a relaxed position during all ironing operations. Pressure of the forefinger or thumb moves the iron to the left or right. The palm fitting handle eliminates tight gripping or awkward wrist positions. Deep pockets, sleeves and seams are easily entered due to the open construction. Designed by Westinghouse, the iron weighs four pounds, has a 1000-watt heating element embedded in the sole plate and a side mounted attachment cord.

Precision Instrument Designed for Rapid Use

NEW optics and precision gearing, incorporated in the quartz orientation unit at right, make it possible to hold tolerances in quartz orientation to less than one minute of arc. Built by North American Philips Co. Inc., the instrument is 30 inches long and has its cabinets finished in black crackle. The control panel is arranged for simple, convenient and rapid use. Useful in the field of communications where quartz crystals for control of frequency are again receiving much attention from electronics engineers, the unit includes a high-capacity air-cooled generator, a single-phase built-in stabilizer, an air-cooled X-ray tube, rapid tube interchange, fixed kilovoltage, variable milliamperage, and combined milliampere and count-rate meter. Having a direct reading scale, the angle measuring unit has been especially designed for quartz measurement. The fixed divergence slit and the fixed receiving slit each measure 0.005-inch. Gearing is precision hardened and the crystal holder has a Carboloy tip. Beam shutters are mechanical, one being provided on the X-ray tube housing and one on the divergence slit assembly. The Geiger counter employed is designed for high sensitivity and long life.

Automatic Stapler Facilitates Assembly

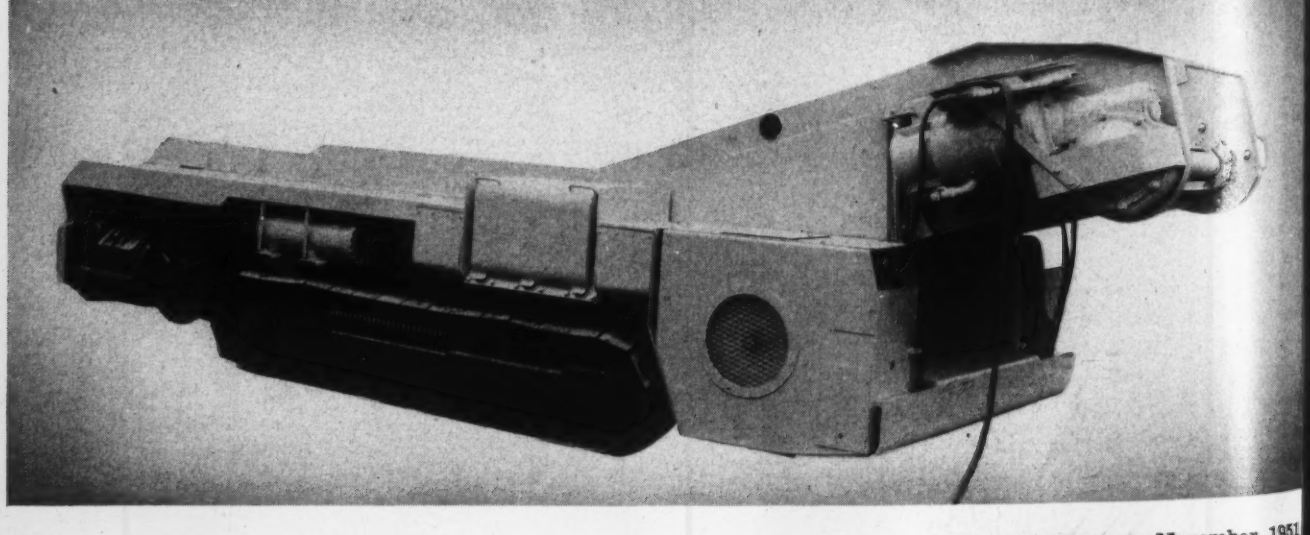


MAGAZINE-FED rings in the compact "hog-ring" pliers at left simplifies the assembly of fabric or other materials on wire frames. It is also useful for fastening electric wires into harness assemblies. Wire, rods, cords and cables up to ½-inch in diameter can easily pass through the open staple which can be closed as small as 5/16-inch in these pliers designed by Bostitch Inc.

Increases Maneuverability of Mine Car

DESIGNED for operation in close quarters, the General Electric shuttle car illustrated below has a turning radius of 14 to 16 feet. Radically different from previous shuttle cars for mining service which use rubber-tired wheels, this crawler-type steel-track unit requires no clearance for turning wheels, thus allowing a wider conveyor in the body for the same overall width. Simplicity in design is achieved through the use of a drive motor on each track, eliminating complicated gears, driveshaft and steering mechanism. Each track is driven by a sealed type, 20-hp, series-wound motor through single-gear reduction, chain and sprocket. The gear case is an integral part of the motor. One sealed type, 3-hp compound-wound motor drives the hydraulic auxiliaries and two 5-hp compound-wound gearmotors drive the conveyor chain.

Two steering levers at the operator's position control the tracks. They are connected to the traction motor circuits and to hydraulic brake valves. Motor acceleration and reversing is accomplished by foot button to actuate magnetic contactors through time-delay relays, providing 3-step starting. The track carriage is hinged to the body at the track drive end and flexibly connected at the front end by a torsion spring. The track linkage consists of forged hardened steel side links with hardened steel pins and bushings, and the shoes are hardened wear-resistant steel. Each track runs on six rollers and is supported over the top by two idler rollers, positioned by recoil springs to absorb shock and maintain tension.



Selecting Manual Controls

. . . for increased efficiency

By Louis E. Davis

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Berkeley, Calif.

ONE of the most important factors in increasing machine efficiency is the manual control, for manual controls are primary connecting links between machine and operator. Style, size, height, angle and frictional torque load of the control all have an influence.

Determination of how these variables interlock and of optimum values for each of them was the purpose of an experiment previously reported in MACHINE DESIGN.* This original test involved the accurate setting of an indicator by manipulating a handwheel, crank or crossbar. Simulating the setting of a machine, one full revolution of the control device was employed and was intended to provide a guide to situations involving repeated revolutions of the control to make a setting. A variety of sizes were used. Control devices were mounted at different heights and

*See bibliography at end of article.

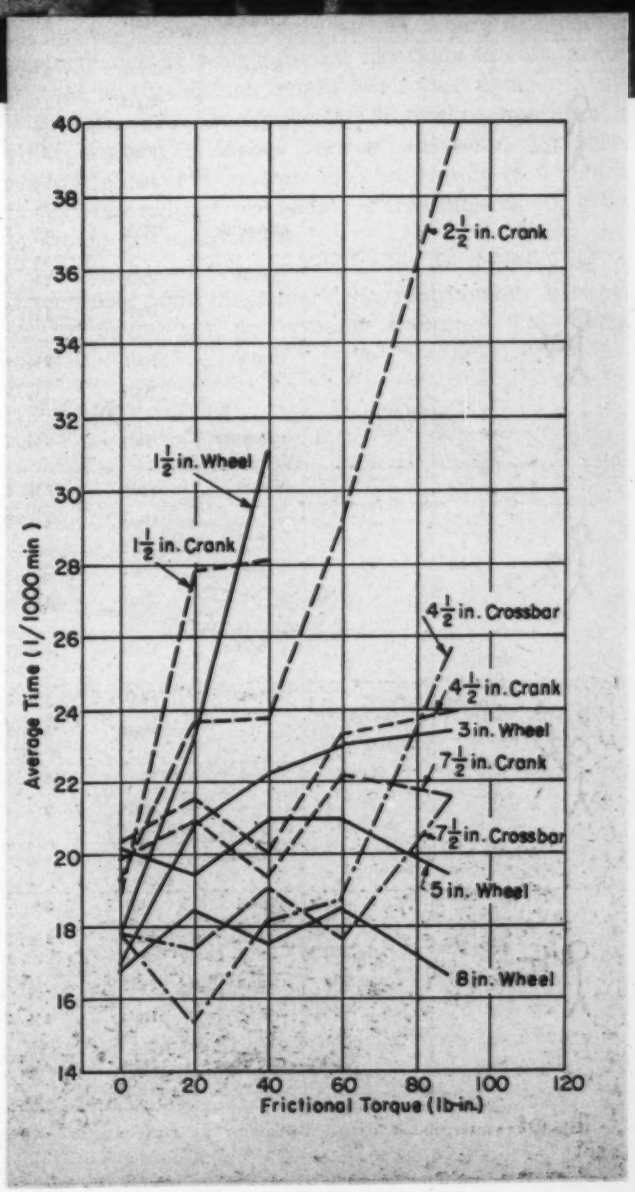

Fig. 1—Test results for manual controls at 36-inch height, horizontal axis of rotation, with operator facing the control. Similar analyses were prepared for other heights, angles and positions. Sizes are radii

Table 1—Optimum Size of Control Device

Angle of Axis (deg)	Height Above Floor (inches)	Type of Control	Operation (turns)	Size of Control (inches, radius)				
				0 lb-in. torque	20 lb-in. torque	40 lb-in. torque	60 lb-in. torque	90 lb-in. torque
0	24	Wheel	Full	1½, 3	3*	5	5*	5
			Half	1½, 3	8	8	8	8
		Crank	Half	4½	7½	4½, 7½	4½, 7½	7½
		Crossbar	Half	7½	4½, 7½	7½	4½, 7½	4½, 7½
0	36	Wheel	Full	1½, 3, 4	5, 8*	5, 8	5, 8	8
			Half	1½, 3, 8	5, 8	8	8	8
		Crank	Full	1½, 2½, 3½, 4½	2½, 3½, 4½, 7½*	4½, 7½	4½*, 7½*	4½, 7½
			Half	1½, 2½, 7½	4½, 7½	4½, 7½	4½, 7½	7½
		Crossbar	Half	4½, 7½	4½	4½, 7½	4½, 7½	7½
07	36	Wheel	Full	1½, 3	5	5	5*	5
			Half	1½, 3, 8	8	8	8	8
		Crank	Half	1½, 2½, 4½, 7½	4½, 7½	7½	4½, 7½	7½
		Crossbar	Half	4½, 7½	7½	4½, 7½	4½, 7½	7½
90	39	Wheel	Full	1½, 3, 5	5	5, 8	8*	8
			Half	1½, 3, 5, 8	3, 5, 8	3, 5, 8	8	8
		Crank	Full	2½, 3½, 4½	2½, 3½, 4½*	4½, 7½	4½*, 7½*	4½, 7½
			Half	1½, 2½, 4½	4½, 7½	4½, 7½	7½	7½
		Crossbar	Half	4½, 7½	4½, 7½	4½, 7½	4½, 7½	7½
−45	40	Wheel	Full	1½, 3	5, 8	3, 5, 8	5*, 8*	5, 8
			Half	1½, 3	3, 5, 8	8	5, 8	8
		Crank	Full	2½, 4½, 7½	2½, 4½, 7½	4½, 7½	4½*, 7½*	4½, 7½
			Half	1½, 2½, 4½, 7½	4½, 7½	4½, 7½	4½, 7½	7½
		Crossbar	Half	4½, 7½	4½, 7½	7½	4½, 7½	7½
+45	42	Wheel	Full	1½, 3	3, 5	5	5*	5, 8
			Half	1½, 3	3, 5, 8	5, 8	5, 8	5, 8
		Crank	Full	2½, 4½	2½, 4½	2½, 4½	4½*	4½
			Half	1½, 2½, 4½, 7½	2½, 4½, 7½	4½, 7½	7½	7½
		Crossbar	Half	4½, 7½	4½, 7½	7½	4½, 7½	7½
0	48	Wheel	Full	1½, 3	3, 4, 5, 8	4, 5, 8	5, 8	5, 8
			Half	1½, 3, 5, 8	3, 5, 8	5, 8	8	5, 8
		Crank	Full	2½, 3½, 4½	2½, 3½, 4½, 7½*	4½	4½*, 7½*	4½, 7½
			Half	2½, 4½, 7½	4½, 7½	7½	4½, 7½	4½, 7½
		Crossbar	Half	7½	7½	7½	4½, 7½	7½
0	58	Wheel	Full	3*	3*	3,* 5*, 8*	5*, 8*	5*
			Half	1½, 3	8	5, 8	5, 8	5, 8
		Crank	Full	2½*, 4½*	2½, 4½	2½, 4½	4½	4½
			Half	1½, 2½, 4½, 7½	2½, 4½, 7½	2½, 4½, 7½	4½, 7½	7½
		Crossbar	Half	4½, 7½	4½, 7½	4½, 7½	4½, 7½	4½, 7½

* Based on interpolated data. † Operator at right angles. All others facing.

angles. They were operated at torques ranging from zero to ninety pound-inches.

A survey of the results indicated that further investigation was needed of the condition in which the control is turned only a part of a revolution. This control situation constitutes an important activity in many machine settings. Suspicions that partial-revolution optimum values would be significantly different from those obtained with a full revolution have been fully confirmed and are outlined in this article.

TYPICAL ANALYSIS: Tests involving a partial revolution were made under the same conditions as full-revolution tests. After completion, graphs of performance were prepared. As an example, *Fig.* 1 shows the results of the partial-revolution test for 36 inches height with axis of rotation parallel to the floor and operator facing the handwheel. This height and position is most representative of actual control-device location on standard machine tools.

With this situation handwheels give a better performance than cranks and crossbars for all comparable sizes at all torques. The comparison between wheels and crossbars is not clear-cut. In smaller sizes wheels are superior; in intermediate sizes crossbars give better performance; and in large sizes there is no essential difference between them.

The largest sizes of crank and wheel perform best at all torques and are least affected by torque. In general, progressively poorer performance is caused by either an increase in torque or a decrease in size of control device. With larger-size controls, differences in torque below 40 lb-in. have no pronounced effect. For smaller sizes, best performance is at zero torque. Comparison of the results of this experiment with the one requiring a full revolution indicates that cranks are better than wheels for a full revolution, whereas the situation is reversed for the partial revolution.

By analyzing test findings in this manner, a clear indication of optimum sizes and types of control device for various positions and torques was obtained. These results, for both full and half-revolution tests, are indicated in TABLES 1 and 2. The tests also indicated that certain heights, angles and torques are in themselves superior.

RESULTS—FULL REVOLUTION: For a full revolution, cranks give better performance than wheels at 36 and 48-inch heights, and for high torques at plus 45 degrees axis. At 39 inches vertical, 58 inches horizontal, and minus 45 degrees axis, cranks and wheels are comparable.

For small control devices (1½ to 3½-inch radius), optimum operation is obtained at minimum (0 lb-in.) torque for all locations. For large control devices (4 to 8-inch radius) the optimum condition is at 20 to 40 lb-in. of frictional torque at all locations.

Except for the minus-45-degree axis of rotation, 40-inch height, where performance is better, and at 36 inches, operator at right angles, where it is poorer, performance of wheels at all locations is comparable to that at the 36-inch height horizontal axis.

Performance by cranks at 36 inches operator at right angles, 39 inches vertical axis, and 58 inches horizontal axis is poorer than at the 36-inch height horizontal axis of rotation. Performances at other locations are comparable.

For each control location there is a breaking or divergence point at which the relationship between size of device and performance changes. This diver-

Table 2—Optimum Type of Control Device

Angle of Axis (deg)	Height above Floor (inches)	Operation (turns)	Type of Control*				
			0 lb-in. torque	20 lb-in. torque	40 lb-in. torque	60 lb-in. torque	90 lb-in. torque
0	24	Full	W only tested				
		Half	W, CB	CB	W	W	W
0	36	Full	W, C	C	C	C	C
		Half	W, CB	CB	W, CB	W, CB	W
0†	36	Full	W only tested				
		Half	C, CB	W	CB	W	W, C, CB
90	39	Full	W, C	W	W, C	W, C	C
		Half	W, C	W	W, CB	CB	CB
−45	40	Full	W, C	C	C	W, C	W, C
		Half	W, CB	W, CB	W	W, CB	W
+45	42	Full	W, C	W, C	W, C	W, C	C
		Half	W, CB	W, CB	W, CB	W	W
0	48	Full	C	C	C	C	C, CB
		Half	CB	CB	W, CB	W	W
0	58	Full	W	W, C	W, C, CB	W, C	C
		Half	W, CB	W, CB	CB	CB	W, CB

*W=wheel, C=crank, CB=cross bar. †Operator at right angles. All others facing.

gence point is at 20 to 40 lb-in. torque for a full revolution. Above this point the bigger the control device, the better the performance achieved; below this point the smaller the size of control device, the better the results. Above the divergence point, when frictional torque grows larger, the difference in favor of larger control devices also becomes greater.

In general, small control devices perform best at zero lb-in. torque, and this performance is comparable to the best turned in by all sizes of devices at all torques. Effectiveness of small-size controls drops off sharply above zero lb-in. torque. At the intermediate torque range, 20 to 40 lb-in., medium-size controls (4 to 5-inch radius) are most effective. For largest torques, the largest sizes are best.

RESULTS—PARTIAL REVOLUTION: In most cases, the half-revolution test showed different results from the full-revolution test. Thus, wheels give better performance than cranks under all conditions except where operator is standing at right angles to the control device, and here performance is mixed. Crossbars in a number of instances give a performance that is equal to that of wheels.

For small control devices (1½ to 3-inch radius) best performance is obtained at minimum torque for all locations. Any increase in torque above zero lb-in. results in a marked reduction in performance.

The intermediate-size wheel of 5-inch radius is best at 20 to 40 lb-in. torque for most locations. The intermediate-size crank (4½-inch radius) operates best at zero lb-in. torque at all locations except at 36 inches horizontal, 40 inches minus 45 degrees, and 48 inches horizontal. At these locations optimum operation is obtained at 20 to 40 lb-in. torque.

Torque influences the largest-size wheel (8-inch radius) only slightly but a little better performance is obtained at 20 to 40 lb-in. The largest size crank (7½-inch radius) operates best at zero to 40 lb-in. torque, and as torque is increased above 40 lb-in. performance is adversely affected.

Most Satisfactory Location

Regardless of the type and size of the control device or the torque at which it is operated, the 40-inch height minus-45-degree location is more satisfactory than the 36-inch horizontal-axis location which can be considered as typical. With few exceptions performance at this 40-inch height for all conditions is superior to any other position. For comparable sizes of devices and at all torques, performance at the 42-inch height plus-45-degree location is superior to that at 36 inch horizontal axis.

The divergence point at 20 to 40 lb-in. torque which is so noticeable in the full-revolution operation is much less prominent for the one-half-revolution operation. Nevertheless, above this point (that is for greater torques) the larger the control device, the better performance achieved; below this point the effect of size on performance is mixed.

In general, most effective operation of small control devices is at zero lb-in. torque and this performance is comparable to the best for all sizes at all torques. The effectiveness of small sizes of control devices drops off sharply above zero lb-in. For all torques above this value, the larger the device the better the performance.

To determine whether or not direction of rotation had any bearing, each of the tests was performed in both clockwise and counterclockwise direction. Although each of the operators was right-handed, there was no significant difference in performance which can be attributed to direction of rotation.

GENERAL CONCLUSIONS: In reviewing and comparing all the data collected, certain points stand out. Some of these conclusions merely confirm present machine design practices. Others seem to indicate that present practices could be improved.

Wheel with Crank Handle Best

For operations involving accurate settings by means of manually operated control devices, the optimum type of device is a wheel with a protruding crank handle. This control permits crank type operation for rapid traversing or turning through a number of turns to bring the indicator to a setting. The same device can be used as a wheel where a partial turn is required.

Location of the controls at 40 inches height minus 45 degrees axis, operator facing control, gave the best performance for both full and partial revolutions. This would indicate that further tests in actual work situations should be undertaken.

Considering the interrelations of height, location and frictional load, one of the most striking results is the relative consistency of performance. Performance is surprisingly independent of position and orientation of control and operator.

Direction of rotation has no effect on speed of achieving an accurate setting. The most important components which affect the performance are type of device, frictional torque and size of device. These are interrelated. As torque is increased performance is retarded, and small-size controls are more greatly affected than large.

If the load on a device can be selected by the designer it should never be permitted to exceed 40 lb-in. torque. If load can be eliminated entirely, then the widest choice of control size is available to the designer—from the smallest to the largest. Should some load be present, it appears to be advisable to keep the load at 20 to 40 lb-in. of torque, at which point the best performance is attained with the largest-size controls. For loads greater than zero lb-in., the largest control device will provide the best performance.

The author wishes to express his appreciation for assistance to J. Goffman of Columbia Steel Co. Head photo, courtesy Balcrank Inc.

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Fig. 1.—Setup employed to determine experimentally the WR^2 of a large electrical rotor

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How To Measure WR^2 of Balanced Rotors

ACCURATE knowledge of the moment of inertia of balanced rotors, generally referred to as WR^2, is essential to the proper design and application of many machines. Calculations for WR^2 frequently are laborious and complex, with considerable chance of error. The simple test procedure explained in this article can serve as an accurate check on the calculations and give confidence in predicting actual performance. Its use may save a costly failure.

In this test, with the statically balanced rotor resting on two parallel and level rails at equal journal diameters, a known unbalance is added, *Fig.* 1. The time for a complete oscillation is measured as the rotor rocks back and forth on the ways. Of course the added weight must not shift its position with respect to the rotor as the assembly rocks, and the journals resting on the ways must be perfect circles concentric with the shaft and of equal diameter. It may be necessary to provide a bushing for one journal to make the diameter of both journals equal. The added WR^2 should lie between 5 per cent and 100 per cent of the WR^2 of the rotor.

On small rotors the weight may be wired on the outside diameter. One method of attaching large weights to large rotors is illustrated in *Fig.* 1. The WR^2 of the attachment arm is usually negligible compared to that of the rotor and weights; however, its unbalance moment should be included.

WORKING EQUATION: Referring to the schematic diagram in *Fig.* 2, an equation may be set up by taking moments about the point of contact with the rails:

$$-W_w b \sin\theta - W_a b_a \sin\theta = \left[\frac{WR^2}{g} + \frac{Wa^2}{g} + \frac{W_w c^2}{g}\right]\frac{d^2\theta}{dt^2} \quad \ldots\ldots (1)$$

where

W = Rotor weight, pounds
W_w = Added weight, pounds
W_a = Weight of attachment arm, pounds
R = Rotor radius of gyration, feet
a = Journal radius, feet
b = Radius to center of gravity of weight, feet
b_a = Radius to center of gravity of attachment arm, feet
c = Distance from point of contact with rails to center of gravity of weight, feet
g = Gravity acceleration, feet per second per second
θ = Angular displacement of rotor from equilibrium position, radians

For small angular displacement (up to 15 degrees amplitude) it is sufficiently accurate to assume $\sin\theta = \theta$ and $c = b - a$, which simplifies Equation 1 to

$$0 = \frac{d^2\theta}{dt^2} + \frac{(W_w b + W_a b_a)g\theta}{WR^2 + Wa^2 + W_w(b-a)^2} \quad \ldots\ldots (2)$$

Solution of this differential equation follows well-known rules. However, it may be pointed out that angular *displacement* θ and angular *acceleration* $d^2\theta/dt^2$ are proportional. This relation being char-

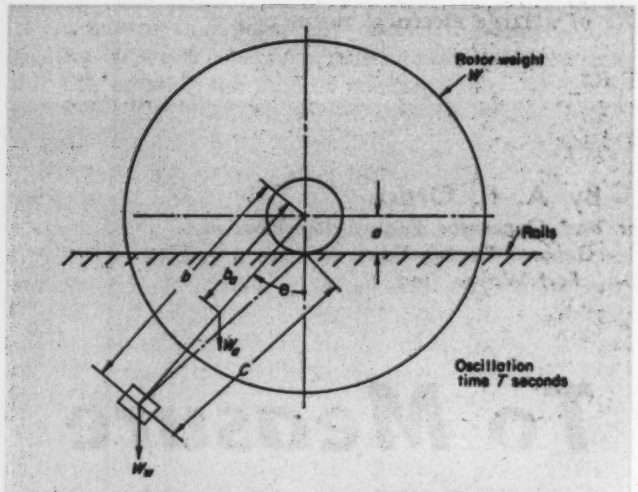

Fig. 2—Diagram of rotor WR^2 test setup, showing definition of terms used in developing the working equations

acteristic of simple harmonic motion, it is possible to say that the solution must be of the general form $\theta = A \sin(\omega t + \alpha)$ where A is amplitude of angular motion, ω is frequency, radians per second, and α is an angle of lag. Substituting this value of θ in Equation 2 and solving for ω

$$\omega = \sqrt{\frac{(W_w b + W_a b_a)g}{WR^2 + Wa^2 + W_w(b-a)^2}} \quad \ldots\ldots\ldots\ldots (3)$$

Time for a complete oscillation cycle is $T = 2\pi/\omega$, therefore $\omega = 2\pi/T$. Substituting this value of ω in Equation 3 and solving for WR^2:

$$WR^2 = 0.814(W_w b + W_a b_a)T^2 - Wa^2 - W_w(b-a)^2 \quad \ldots\ldots (4)$$

SAMPLE CALCULATION: The following calculations are for the large rotor shown in *Fig.* 1. In addition to the simple calculation based on Equation 4, the relative effect of refinements which take into account the moments of inertia of the attachment arm about the point of contact with the rails, and of the added weight about its own c.g., will be demonstrated.

Data are $W = 3880$ lb, $W_w = 86.5$ lb, $a = 3.19$ inches, $b = 36.06$ inches, $W_a = 10$ lb, $b_a = 12.94$ inches, and $T = 4.54$ sec. Substituting in Equation 4,

$$WR^2 = 0.814\left(\frac{86.5 \times 36.06 + 10 \times 12.94}{12}\right)4.54^2 -$$

$$3880\left(\frac{3.19}{12}\right)^2 - 86.5\left(\frac{36.06 - 3.19}{12}\right)^2$$

$$= 4542 - 274 - 649 = 3619 \text{ lb-ft}^2$$

To determine the effect of the two refinements, the following additional data are needed: radius of gyration of arm about its own center, $k_a = 12.22$ inches, and radius of added weight, $R_w = 10$ inches.

Effect of the moment of inertia of the arm referred to the point of contact with the rails should be subtracted from Equation 4. It is made up of two terms:

$$W_a(b_a - a)^2 + W_a k_a^2$$

$$= 10\left(\frac{12.94 - 3.19}{12}\right)^2 + 10\left(\frac{12.22}{12}\right)^2 = 17 \text{ lb-ft}^2$$

Effect of the moment of inertia of the added weight about its own axis through its center of gravity, parallel to the shaft axis, should also be subtracted from Equation 4. The added weight being in the form of a solid cylinder, its moment of inertia is

$$\tfrac{1}{4} W_w R_w^2 = 0.25 \times 86.5\left(\frac{10}{12}\right)^2 = 15 \text{ lb-ft}^2$$

These effects subtracted from Equation 4 give the corrected WR^2 of the rotor:

$$3619 - 17 - 15 = 3587 \text{ lb-ft}^2$$

which represents a difference of less than one per cent of the more accurate figure. It is therefore evident that Equation 4 is sufficiently accurate for most engineering purposes.

Calculated WR^2 of the rotor shown in *Fig.* 1 was 3435 lb-ft², about 4.3 per cent on the low side of the accurate test value. In a series of calculations and tests on rotors having WR^2 values from 46 to 7573 lb-ft², the calculated values varied from 1.25 per cent high to 4.5 per cent low.

Where WR^2 is important

In *engine-driven synchronous generators* the rotor WR^2, the shaft stiffness and the electrical "stiffness" determine the natural torsional vibration frequencies. These natural frequencies must not coincide with any appreciable harmonic component of engine torque or critical vibrations will occur, leading to shaft failure by fatigue. A similar problem arises in reciprocating compressors driven by synchronous motors.

Waterwheel generators have guaranteed minimum WR^2 because sudden loss of electrical load permits the hydraulic turbine to overspeed during the appreciable time the governor is reducing the water flow. Insufficient WR^2 permits excessive overspeed or speed changes which may affect system frequency.

Motor starting performance is determined by WR^2 of the rotor and the electrical windings, including the amortisseur or damper winding of induction and synchronous motors. If WR^2 of an actual motor is accurately known, motor starting performance curves may be obtained by measurement of the acceleration rate.

Stored energy, a function of WR^2 in rotating parts, determines the revolutions to stop during dynamic braking of rubber mill motors, vehicles, printing press drives, textile machinery, etc. Operating time of control devices therefore depends on WR^2 of rotating parts.

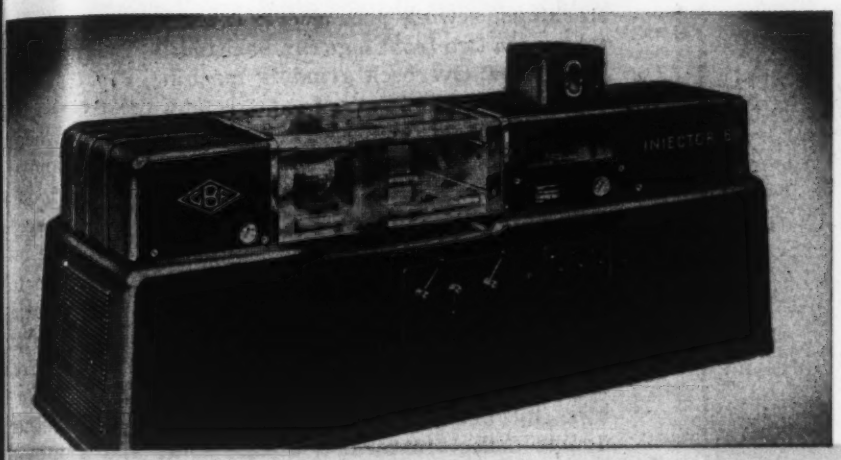

Fig. 1—Automatic injection molding machine for thermoplastics handles charges from 1 to 6 oz. Construzione Meccaniche GBF, Milano, Italy

European Design Trends

By Paul Grodzinski
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MACHINES shown at recent main Continental and the British Industries fairs reveal that in all countries increased emphasis has been placed on improving appearance of the machines. Many designers have followed the idea of a not-too-well understood "streamlining" but, in general, each country seems to have developed its own style in their new products, as is shown by the following typical examples.

There is a tendency in Romanic countries to ignore the purpose of the machine and to give it a cupboard type appearance, as on the Italian injection molding machine, *Fig.* 1. Were it not for the transparent plastic cover of the mold closing mechanism and the dies, it would be difficult to guess what the machine is for. There is, of course, no objection to the progressing tendency to cover the machines against ingress of dust and to protect the surroundings from the machine. *Fig.* 1 shows the modern solution of this problem—use of glass or transparent plastic covers. *Fig.* 2 shows a packaging machine for producing airtight packages from transparent bands. It takes cellulose acetate bands up to 0.006-inch thick and polymerized films 0.0021-inch thick.

Well-balanced styling is incorporated in the tablet presses made by W. Fette, *Fig.* 3. The machines have three feeds and can supply up to 2400 tablets per hour of $1\frac{1}{16}$ to 2-inches diameter with one punch; for smaller tablets $\frac{1}{8}$ to $\frac{3}{16}$-inches in diameter, up to 60,000 tablets per hour can be produced.

In sewing machines, important constructional development could be seen. The Zundapp Co. has developed a new machine in a cast aluminum housing, *Fig.* 4, with the lamp in an aircooled, protected holder. The machine with accessories weighs only 20 pounds and is easily portable. A further attempt at improving appearance of the sewing machine is the arched overhead arm, as in the Waldorp Roto-Stitch machine, *Fig.* 5. A special feature of this machine is the projecting arm which can be used for darning

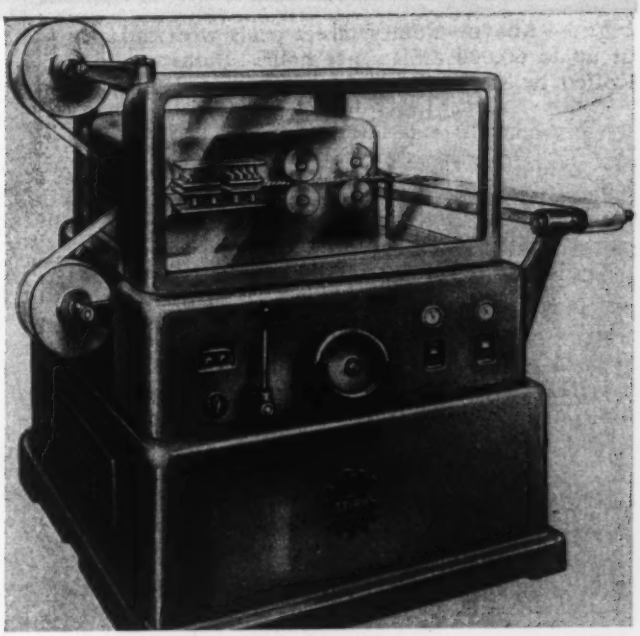


Fig. 2—Tablet packaging machine for sealing tablets into transparent plastic foil. Stirnwerk, Walter Stirn, Wurttemberg, Germany

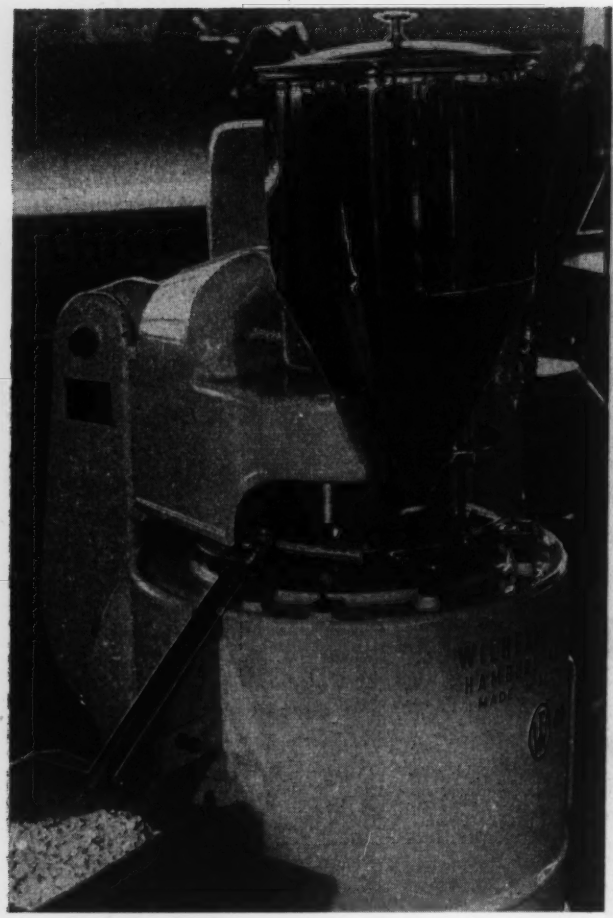


Fig. 3—Above—Rotary tablet press with capacity of up to 60,000 tablets per hour. Rams are controlled by stationary cams. W. Fette, Hamburg-Altona, Germany

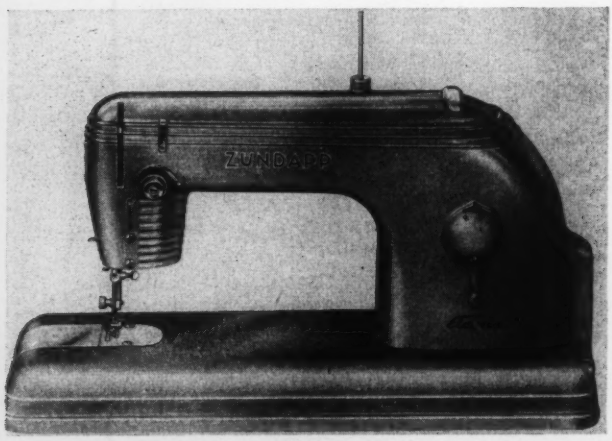


Fig. 4—Left—Sewing machine: for domestic use, 1000 stitches per minute; for commercial use, up to 2500 stitches per minute. Zundapp, Munich, Germany

Fig. 5—Left, below—Waldorp Roto-Stitch domestic sewing machine. N. V. Handelsmaatschappij Hostaco, Dordrecht, Holland

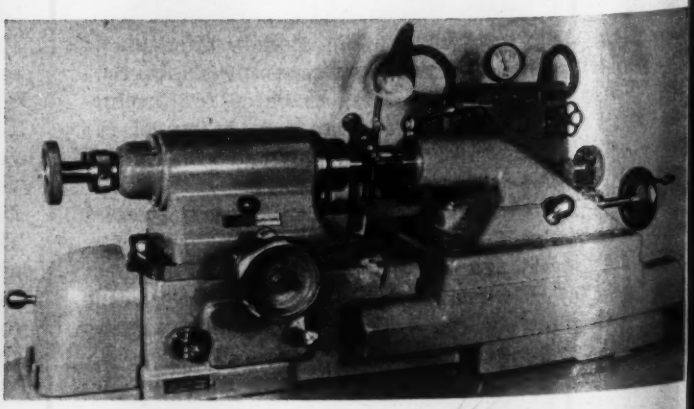


Fig. 6—Below—New high-speed tool grinding machine, preferably for use with diamond grinding wheels.

stockings, sewing arm sleeves, etc.; for flat work, a table with two front legs can be fitted.

The new Overbeck grinding machine, *Fig.* 6, is rigidly built for high spindle speeds (up to 80,000 rpm) and is intended for use with diamond grinding wheels.

A teabag packaging machine shown at Hanover, *Fig.* 7, looks like a kinematic model arranged on a backplate for study. Actually it is a high-speed working machine, producing 140 to 160 complete teabags per minute. In the machine, filter paper fed from a reel passes several rollers and the rotating drum of the dosing device from which an accurate amount of tea drops into each of the two sections on the filter paper. The paper is then formed into a tube by bringing the edges of the web together; double deflectors form a double fold; and a moving knife cuts a piece from finished tube sufficient to make one bag.

Interesting developments in improving the appearance of special machines and cabinets should be mentioned. The Widney Dorlec cabinet system consists of a series of prefabricated diecast corners, extruded sections and various other components which enable modern fully radiused cabinets and racks, *Fig.* 8, to be built without special tools. For instance, a simple framework can be built from eight diecast corner pieces, one at each corner, connected by specially shaped sections cut to required lengths. Special brackets can be fitted in the base for slide rails. While developed originally for housing communication equipment, this equipment is eminently useful for the arrangement of special machines, laboratory equipment in particular.

Several variable-speed drives have been developed in the various countries. Quite a number of these gears have made their way from one to the other country. The original English PIV-gear was featured both in France and Germany. The German

Heynau friction gear with conical friction ring is manufactured in several countries, but is still most favored in Germany. A French variable-speed gear FU (Fabrication Unicum) with double conical rollers between flat disks has been built in England for a number of years. The Swiss Klopp friction gear with balls, *Fig.* 9, is now manufactured both in Germany and England. Smaller units of this gear definitely appear to be the cheapest variable-speed gear yet produced. Ball-shaped friction rollers run against two conical disks; inclination of the ball axes gives different speeds as distance from axis to contact point is varied. The gear is built in sizes from ¼ to 6 hp, 500 to 4500 rpm.

Slippage Minimized

An extremely simple Prym friction gear was shown in an interesting new combined design, *Fig.* 10. By combining two friction drives, the high ratio of 10 to 1 has been provided. A slip-free movement is obtained by subdividing the connecting shaft between the two disks and by a threaded spindle and special nut having inside and outside threads of opposite direction. Load on the driven shaft causes the threads to generate an axial load and a consequent pressure between the two friction gears; thus, the pressure between the friction disks is controlled by the actual load. Friction load during starting is provided by a helical spring. Reversal of rotation is obtained by reversing the driving motor; flexibility in this process is obtained through a packet of disk springs. Speed control is by rotation of a worm by a handwheel, causing rotation of a drum in which the axis of the main shaft is eccentrically arranged. This drum rotation causes a shift in the contact zones of the friction cones to give the speed adjustment (principle of the Prym friction gears). This new friction gear

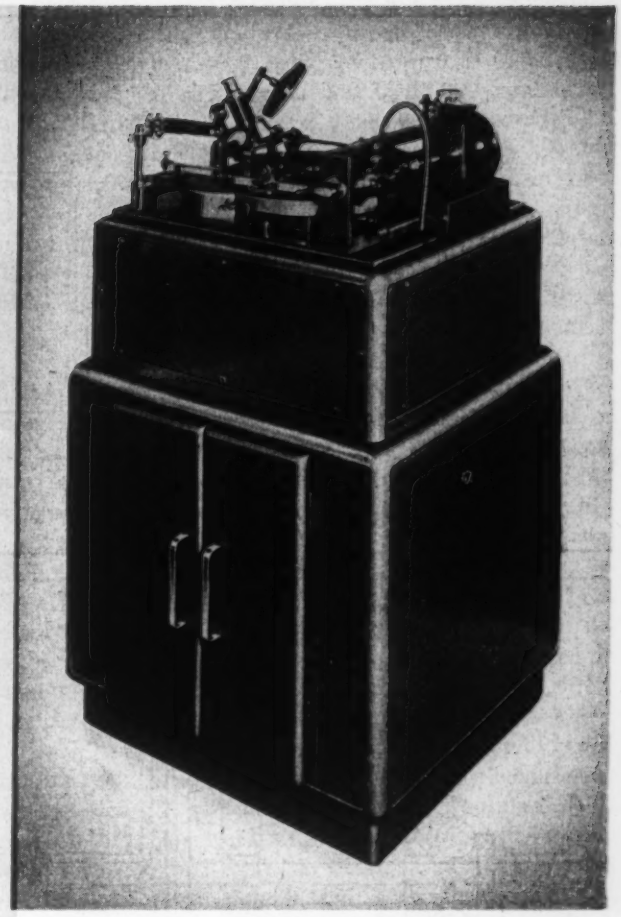


Fig. 8—Above—Special cabinets built by the Widney Dorlec system

Fig. 9—Below—Klopp friction gear has slip not more than 5 per cent at 500 rpm, efficiency of 90 per cent up to 2500 rpm

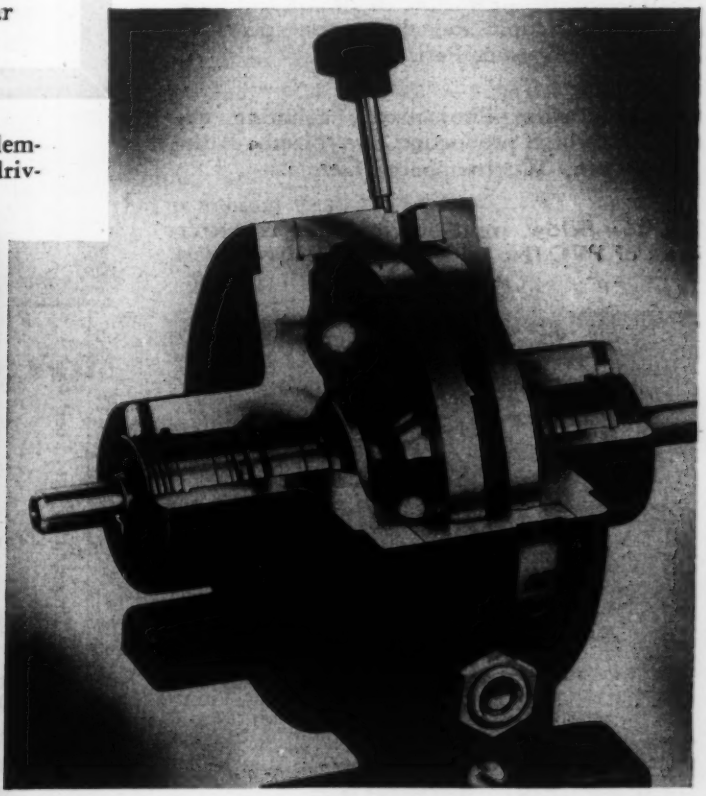
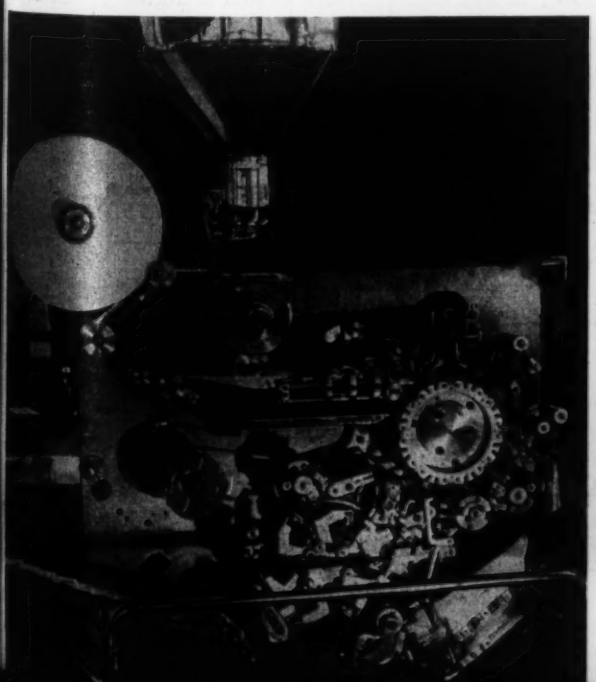


Fig. 7—Below—Teabag machine shown at Hanover demonstrates working mechanism on one side and the driving mechanism on the hidden side



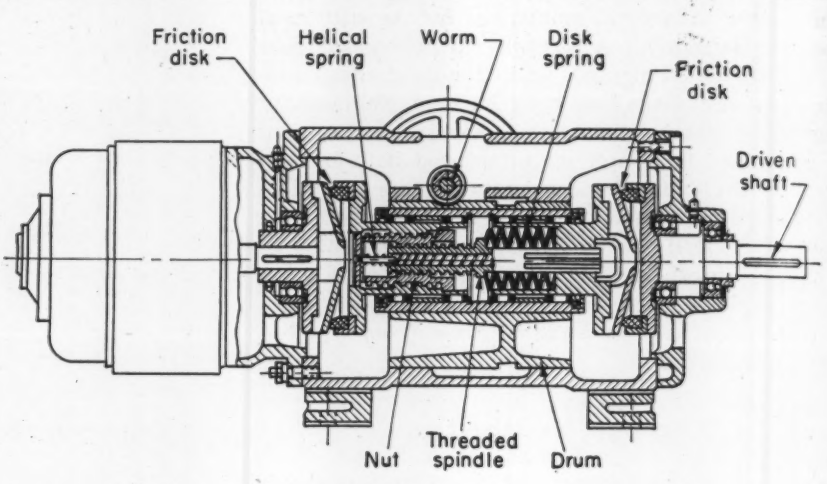


Fig. 10—Section of German Prym SH frictional gear with 10 to 1 speed ratio

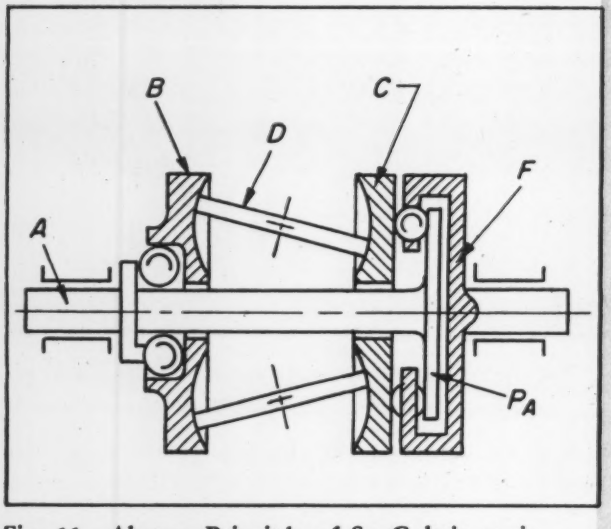


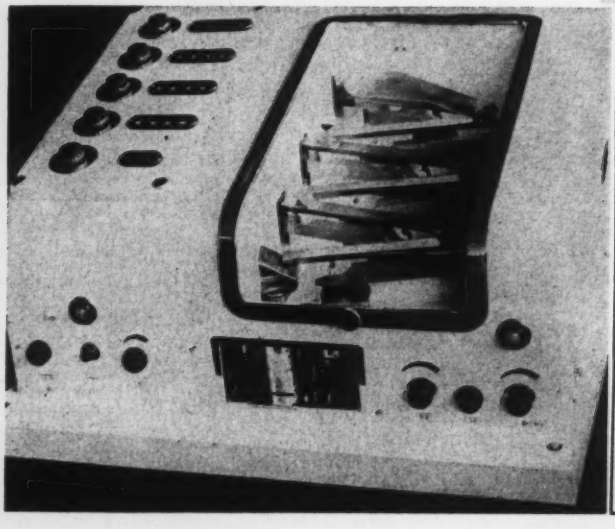
Fig. 11—Above—Principle of St. Gobain variable-speed friction and differential gear. St. Gobain, Paris, France

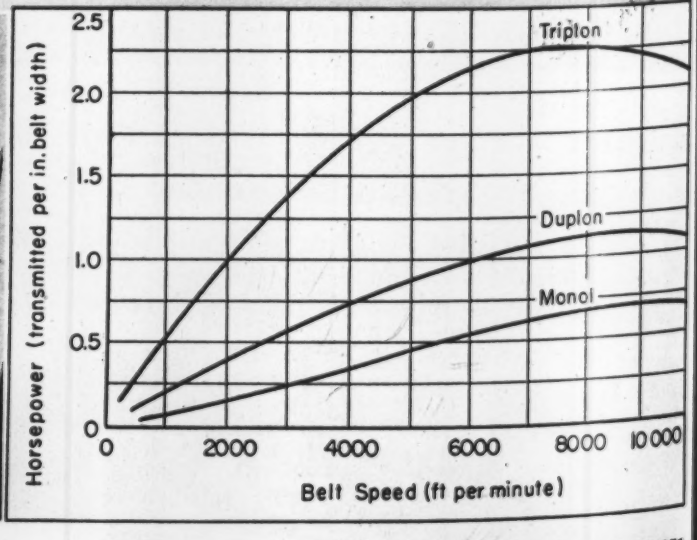
Fig. 12—Below—Photoelectric counting machine with high production rate. Bizerba-Balingen, Wuerttemberg, Germany

Fig. 13—Below, right—Performance characteristics of PVC flat belts made by Habasit Werk A. G., Basle

is built in sizes from 1 to 4 hp and for driven speeds of 140 to 1400 rpm.

The French firm Saint-Gobain showed a further development of a friction gear with toric faces by combining it with a differential to give a zero position and a speed variation in either direction, *Fig.* 11. With a driving speed of $+n$ rpm, the end speed may be varied between $-n$ and $+\frac{1}{3}n$ (by passing through the zero position). Friction forces in the mechanism increase with the resistance. All pressures are balanced in the mechanism itself and no longitudinal forces act on the gear box. The driving shaft *A* (*Fig.* 11) is connected with the toric disk *B*. The opposite disk *C* runs freely on the driveshaft and three rollers *D*, with inclinable axes, are arranged between the two disks. Shaft *A* is connected with a disk P_A. Between disk *C* and P_A a ring of balls is arranged, held in a cage which forms the driven member *F*, to give a differential action. When the pivots of the rollers *D* are vertical, ring *C* rotates with the same speed as disk P_A, but in the opposite direction. This causes the intermediary balls to assume a fixed position in space, and consequently the driven shaft remains stationary. If the pivots of rollers *D* are inclined as shown in *Fig.* 11, i.e., disk *C* has a higher speed than





disk P_A but in the opposite sense, then shaft *F* rotates in the opposite direction to shaft *A*.

Some friction gears do not lend themselves to a vertical arrangement. But both the Heynau and the Klopp friction gears are now available with the main shaft in a vertical direction by providing an oil feed for the upper bearing.

The Carter-Junior fractional-horsepower hydraulic infinitely variable-speed gear is now available for hydraulic gear application hitherto open, for economic reasons, only to the various types of simple friction gears. Speed of the driven shaft is adjustable from full driving speed clockwise through zero to full driving speed counterclockwise without reversing the driving motor. Maximum driving speed is 1720 rpm at which a horsepower of 0.625 can be transmitted; driving torque at all speeds is 23 lb-in.

The Webley electric oscillating fan obtains a controlled oscillating movement of the fan by a reduction gear coupled to the swivelling fan motor which operates a slow-speed crank. This is coupled by a parallel crank with the vertical shutters. These deflect the air stream and the reaction causes the fan to change its direction. Movement is smooth and any obstacle will cause the movement to stop. Speed of oscillation is high enough to give effective cooling over a wide range of movement; one complete oscillation is made in 4 seconds.

High-speed Counting

After extended investigations, Bizerba-Balingen have developed an interesting counting device, *Fig.* 12, for counting small lightweight parts (0.4 to 3mm in diameter or length). The device contains a feeding mechanism and is photoelectrically controlled. It contains no mechanical moving parts except electrically vibrated channels which separate the parts until they come in front of the photoelectric cell. In a test, 10,000 small parts were counted in five minutes with an accuracy of ± 1 to 4 pieces. The device is particularly suitable for the counting of watch parts and watch jewels. It can also be used to dispense a predetermined number of components.

Magnet-hammers of high impact force have been developed by Elmeg, Osterode, for assembly work, particularly riveting operations in electrical apparatus. Hammers with impact energies from 0.75 to 62 lb-in. and impact forces between 550 to 11,000 pounds are produced. Efficient safety devices are provided; in this respect the magnet hammer is ideal as no blow can be exerted without the current being admitted to the coils. A further advantage is that single blows or a series of consecutive blows can be chosen. Devices with several magnet heads one above the other have also been developed, thus increasing impact energy compared with a single arrangement.

The Contina hand calculating machine (53mm in diameter, 85mm long and weighing 230 grams) incorporates a number of novel mechanisms. Built on the principle of the usual adding machines, it contains only a single step roller (Staffelwalze) operating the various counters arranged around it, to make a cylindrical machine. However, the step roller contains two rows of teeth crossing one another. This gives the advantage of using the machine for both addition and subtraction, the latter by using the so-called digit complement. The machine, produced in Liechtenstein, is an example of the precision production possible by using Swiss watch-making machines.

For a number of years, round PVC (polyvinylchloride) belts have been used with good success for driving small high-speed machines. Round and V-belts of this type were shown by Bergeon & Cie., Le Locle and Habasit Werk A. G. Basle 7. While good results have been experienced with these belts on small high-speed machines, the V-belts intended for power transmission up to 1 hp may only be used for horizontal drives and where no overload is expected. At present, round belts are produced from 3 to 15mm diameter, V-belts with profiles from 6 x 4mm to 17 x 11mm, and flat belts from 10 x 3 to 40 x 4.5mm.

The new Habasit X-belt is a flat belt of polyamide (nylon). The belt is nonstretching and therefore transmits loads well, *Fig.* 14, at high speeds, efficiency and adhesion being unaltered by service conditions. Owing to the low specific gravity of the material, centrifugal forces need not be considered. Tensile strength of a 0.8-mm Habasit X-belt is equivalent to that of a 6-mm thick leather belt.

Escalator Design Simplified

DESIGN standardization and simplification of engineering features have facilitated mass production of 48-inch wide escalators at the Otis Elevator Company of New York. The large-capacity escalator will carry 8000 persons an hour, easily accommodating two adults riding side by side.

Although escalators have been built for 50 years, it has not been until recent years that public acceptance increased the demand for the equipment to a point where mass production techniques could be utilized. Driving mechanism, mass produced and factory assembled, will be placed within the truss of the Free-Flow model, eliminating the machine room formerly required by older large-capacity escalators. A worm and gear connect directly to the main drive unit. This arrangement is an improvement over the drive chain used on previous models. The handrail driving mechanism has been simplified.

Heat-treated aluminum alloys, having the proper structural characteristics and wearing qualities, have made unnecessary the cumbersome fastening arrangements used with rolled steel sections. Escalator chain is equipped with rubber-tired wheels in each link. These wheels replace the steel rollers formerly used, greatly reducing the noise resulting from the contact of steel rollers with the sprocket teeth.

Designing a Shockproof Table

By Maurice Ani
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ONLY a half-microinch deflection can be detected by a surface analyzer used on a table specially designed to provide shock isolation from a nearby forge hammer.

Amplitude and frequency of the floor vibrations, in the vicinity of the table, varied with the magnitude of the hammer's blows and the load distribution on the floor. These vibrations were not harmonic but were shocks occurring at irregular intervals. Maximum amplitude was 0.005-inch and the lowest fundamental frequency was about 13 cps.

As a first approximation, a harmonic disturbing force was assumed. The curves show theoretical transmissibility (the ratio of transmitted force to impressed force) versus ω/ω_n for different values of damping ratio C/C_c, where ω = frequency of disturbance, ω_n = natural frequency of the table and suspended system, C = damping constant, and C_c = critical damping.

For low transmissibility, the natural frequency of the system must be much lower than the frequency of the disturbance. For example, with no damping and with a transmissibility of 0.0417, the ratio of disturbing to natural frequency, ω/ω_n, is 5. Added damping increases the transmissibility when ω/ω_n is greater than $\sqrt{2}$. Increasing the transmissibility is undesirable, but in this case damping is necessary to destroy free vibrations rapidly. A transmissibility of not greater than 0.1 was sought.

The weight of the table is increased by steel plates to 600 pounds to nullify any slight change in weight, incurred during use. Four tension springs, attached to channels under the steel plates, carry the total load. They have a static deflection of amost 10 inches under load, which gives the system a low undamped natural frequency. These springs are made of 0.238-inch diameter spring steel wire with 24 active turns having a 3.25-inch outside diameter. Natural frequency of the system is

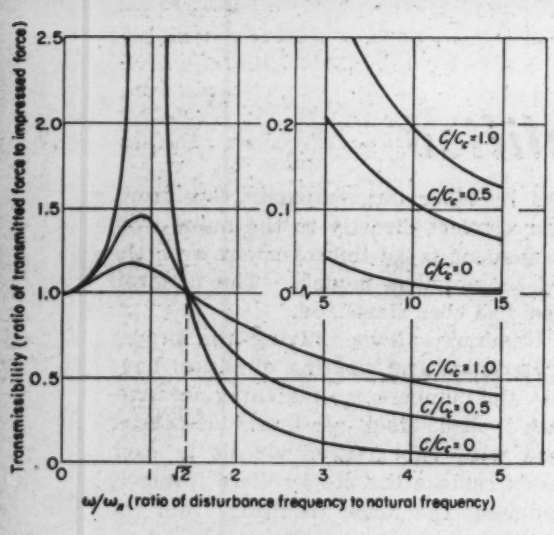
$$\frac{\sqrt{g/d_s}}{2\pi} = \frac{\sqrt{386/10}}{2\pi} = 1 \text{ cps}$$

where g = acceleration due to gravity, in./sec.^{2} and d_s = static deflection, in. The system is designed to have this low frequency for two reasons: (1) Vibrations to be isolated are not harmonic, steady vibrations as assumed by the formula, and (2) damping increases the transmissibility.

The damping is produced by four foam-rubber pads, placed under the table, and six similar pads placed against the sides. The rubber can compress 1½ inches, but to reduce the transmissibility, less than ⅛-inch compression is used. A damping ratio of almost 0.4 was estimated for small amplitudes; hence, the damped frequency is

$$\frac{1}{\sqrt{1-(0.4)^2}} = 1.09 \text{ cps}$$

and ω/ω_n = 13/1.09 = 11.9 which gives a theoretical transmissibility of approximately 0.07.



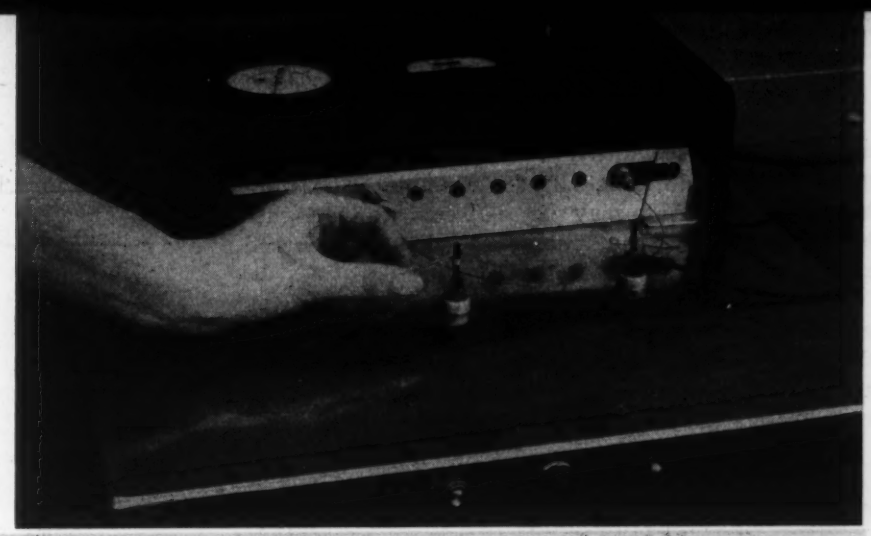


Fig. 1—Rotating-beam fatigue tester developed by Hunter Spring Co. Specimen is a wire bent into a semicircle which is rotated at high speed and thereby subjected to completely reversed bending

Working Stresses for HELICAL SPRINGS

By O. G. Meyers
Hunter Spring Co.
Lansdale, Pa.

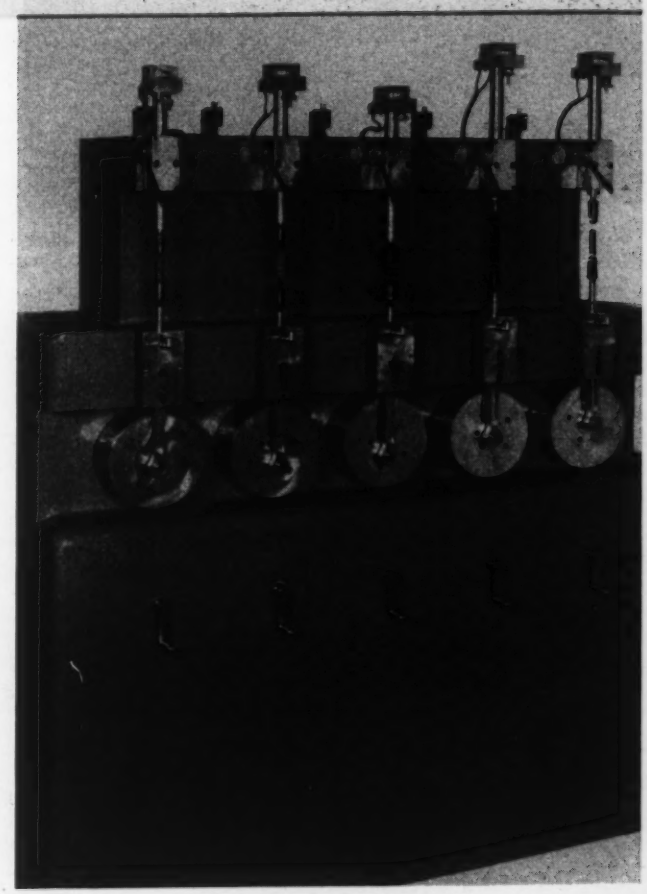


Fig. 2—Krouse spring fatigue-testing machine. Tension and compression springs are tested to failure under simulated service conditions

DESIGN stresses, derived from fatigue tests on spring wire materials, are often given little serious thought by spring designers accustomed to working with prepared charts and forms. Unfamiliar with wire fatigue characteristics, many designers have been in the habit of assuming a standard design stress for a particular spring material under all conditions. In actual fact, maximum allowable design stress is not constant for a given spring material but varies with wire diameter, stress range and required number of operating cycles. If each factor is not considered in selecting design stresses, the spring is usually not designed to its stress capabilities and may either fail unexpectedly or be less efficient and more expensive than necessary.

All meaningful maximum stresses recommended for design are developed from simple *S-N* curves (stress versus number of cycles). Maximum allowable design stress decreases as the number of operating cycles increases until an endurance limit stress is obtained which theoretically permits infinite operating life.

A spring is exposed to most severe stress conditions when it is operated between zero stress and maximum stress. Such a stress cycle represents a full stress range, $(S_{max} - S_{min})/S_{max} = 1.0$. However, springs are often stressed from some intermediate stress to

a maximum, a condition described as a fractional stress range (0.75, 0.50, 0.25, for example). Therefore a preloaded spring may be deflected to a higher stress—and higher maximum load—than an identical spring operating from zero initial stress.

Useful fatigue curves may be obtained by testing either the wire itself, *Fig.* 1, or a spring coiled from the wire, *Figs.* 2 and 3. The rotating-beam fatigue test, *Fig.* 1, has advantages of speed and convenience but subjects the material to completely reversed bending stresses, whereas the loading in an actual tension or compression spring, *Figs.* 2 and 3, imposes torsional shearing stresses. This article shows that *S-N* curves derived from the two types of tests can be correlated, permitting the application of data obtained from fast, convenient rotating-beam tests to be adapted readily to actual spring design.

Fig. 3—Above—Sonntag universal fatigue-testing machine. Large extension and compression springs can be cyclically loaded up to 10,000 lb

Fig. 4—Below—Results of rotating-beam fatigue tests on music wire and stainless steel of two different diameters. Although stresses from these *S-N* curves cannot be used directly in spring design, they can be modified in terms of the shearing stresses which occur in actual tension and compression springs

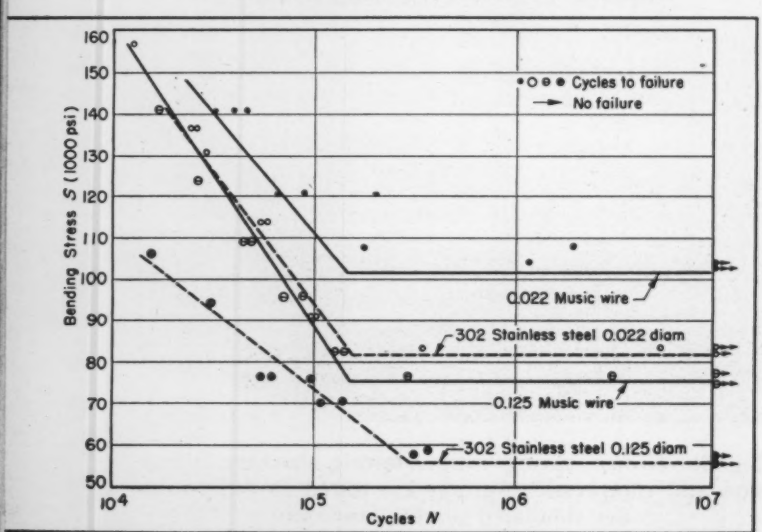


Table 1—Basic Stress

Wire Diameter (gage)	(in.)	Basic Stress* (1000 psi)	Wire Diameter (gage)	(in.)	Basic Stress* (1000 psi)
	.004	143	13	.0915	115
	.005	143	3/32	.0937	113
	.006	142	12	.1055	111
	.007	142	11	.1205	110
	.008	141	1/8	.125	109
	.009	141	10	.135	108
	.010	140	9	.1483	106
	.011	140	5/32	.1562	104
	.012	139	8	.162	103
	.013	139	7	.177	102
	.014	138	3/16	.1875	101
	.015	138	6	.192	100
	.016	137	5	.207	99
	.017	137	7/32	.2187	98
	.018	136	4	.2253	97
	.019	136	3	.2437	96
	.020	135	1/4	.250	95
	.022	134	2	.2625	93
	.024	133	9/32	.2812	92
	.026	132	0	.3065	90
	.028	132	5/16	.3125	89
	.030	131	2–0	.331	88
	.032	131	11/32	.3437	87
	.034	130	3–0	.3625	86
	.036	129	3/8	.375	85
	.038	128	4–0	.3938	84
19	.041	127	13/32	.4062	83
18	.0475	126	7/16	.4375	82
17	.054	124	15/32	.4687	81
1/16	.0625	122	1/2	.500	80
15	.072	120	9/16	.5625	80
14	.080	117	5/8	.625	80

* Corrected for stress concentration.

In *Fig.* 1, 0.022-inch diameter music wire is being tested on the rotating-beam fatigue tester developed by the Hunter Spring Co. for quick and accurate testing of small-diameter wire. Because the stresses to produce failure in small-diameter wire are comparatively high, it is necessary to test such wire at high stresses and high speed in order to minimize time required to cause fracture. With this instrument, for example, spring wire is rotated through 3600 fully reversed stress cycles per minute. In comparison, compression and extension springs are fatigue tested at 550 to 1800 cycles per minute, the speed being limited by the tendency of the spring coils to surge.

In the rotating-beam test a wire specimen is bent into a semicircle and secured at one end in a motor-driven chuck; the other end is free to rotate in an adjustable bushing head, *Fig.* 1. The maximum bending stress produced by rotating the wire occurs at the apex of the loop and may be increased (to reduce the time required for failure) by decreasing the distance between chuck and bushing head.

Table 2—Correction Factor

Spring Material	Stress Range	— Number of Operating Cycles — 10^3	10^4	10^5	Infinite
Music Wire	0.25	1.22	1.12	1.02	0.952
	0.50	1.15	1.00	0.862	0.764
	0.75	1.12	0.944	0.885	0.65
	1.00	1.10	0.91	0.695	0.55
Oil-tempered Spring Steel	0.25	1.10	1.04	0.97	0.926
	0.50	1.063	0.944	0.834	0.752
	0.75	1.04	0.87	0.705	0.595
	1.00	1.00	0.80	0.606	0.458
Hard-drawn Spring Steel and Oil-tempered Chrome Vanadium	0.25	0.944	0.877	0.826	0.787
	0.50	0.91	0.787	0.675	0.606
	0.75	0.862	0.725	0.588	0.485
	1.00	0.834	0.675	0.524	0.414
Stainless Steel Type 302 18-8	0.25	0.877	0.834	0.80	0.77
	0.50	0.84	0.764	0.69	0.636
	0.75	0.813	0.70	0.588	0.518
	1.00	0.78	0.641	0.507	0.913
Phosphor Bronze Spring Wire	0.25	0.513	0.476	0.431	0.392
	0.50	0.472	0.404	0.35	0.303
	0.75	0.435	0.357	0.286	0.239
	1.00	0.394	0.318	0.239	0.183
Beryllium Copper (heat treated)	0.25	0.752	0.725	0.705	0.685
	0.50	0.725	0.675	0.625	0.588
	0.75	0.695	0.625	0.55	0.505
	1.00	0.67	0.578	0.485	0.413
Monel	0.25	0.582	0.547	0.505	0.47
	0.50	0.54	0.476	0.408	0.357
	0.75	0.50	0.422	0.33	0.27
	1.00	0.458	0.368	0.266	0.202
Brass	0.25	0.32	0.303	0.281	0.267
	0.50	0.294	0.266	0.238	0.215
	0.75	0.266	0.238	0.202	0.174
	1.00	0.247	0.21	0.162	0.138

In fatigue testing compression and extension springs, the spring is cyclically deflected between lengths which produce the desired initial and final stresses, *Figs.* 2 and 3. Each test continues until fracture occurs; the number of cycles to fracture and the final (or maximum) stress are recorded. The stress range is, of course, the fraction of the final stress corresponding to the deflection range of the test. The Krouse spring fatigue-testing machine in *Fig.* 2 tests five springs simultaneously; counters record the number of cycles to failure. The lengths between which a spring is deflected are determined by the setting of a counterbalanced adjustable crank which provides continuously variable strokes from zero to two inches.

To test large extension and compression springs, the Sonntag universal fatigue-testing machine in *Fig.* 3, fitted with a tension-compression fixture, is designed to apply cyclical loads as high as 10,000 lb. With properly designed fixtures, simulated service tests on springs, machine elements, structural components and materials can be made with simple or compound stresses in tension, compression, bending and shear.

Rotating Beam Fatigue Test Results

The four *S-N* curves in *Fig.* 4, obtained with a rotating-beam fatigue tester, indicate how fatigue characteristics vary with spring material and wire diameter. The actual test points and curves are for music wire and Type 302 stainless steel, both in 0.022-inch and 0.125-inch diameters. Where the results are not consistent, as at high stresses (low number of cycles), curves have been drawn below the minimum stress points plotted. The discontinuity in each curve is the intersection of the curve for high stresses and the flat curve representing the endurance limit stress for infinite life. Because it has been found that steel springs have infinite life if they do not fail within 10^7 cycles (the figure is 10^8 for certain copper alloys), endurance limit stress is the maximum stress for operation to 10^7 cycles without failure.

For 0.022-inch wire diameter, the endurance limit stress of music wire—102,000 psi—exceeds that of Type 302 stainless steel of equal diameter by almost 20,000 psi. It is clearly unrealistic to design both of these spring materials to the same endurance limit stress.

An increase in wire diameter from 0.022-inch to 0.125-inch decreases the endurance limit stress of both music wire and Type 302 stainless steel approximately 26,000 psi. For music wire this represents a decrease of over 25 per cent, while the endurance limit stress of Type 302 stainless steel has dropped over 31 per cent. In *Fig.* 4, a cycle on a rotating-beam fatigue tester is a complete reversal from zero through both plus and minus indicated stress (stress

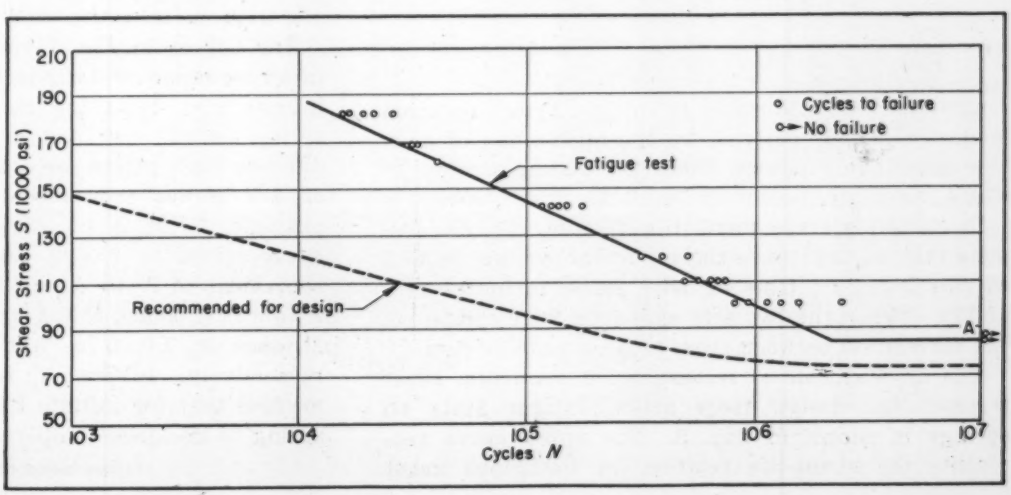


Fig. 5—Results of compression spring fatigue test on 0.022-inch music wire for full stress range (1.0). Recommended design stress (dotted curve) includes safety margin of 13 per cent at endurance limit, more at higher stresses

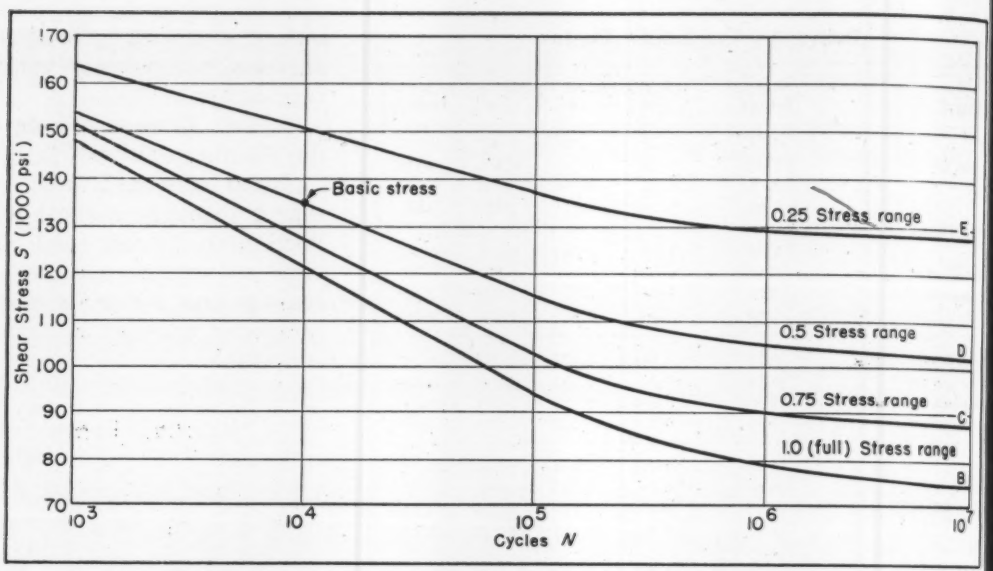


Fig. 6—Right—Maximum recommended design stresses for 0.022-inch music wire for various stress ranges. Stress characteristics of other spring materials are referred to music wire at 0.50 stress range and 10,000 cycles—called *basic stress*

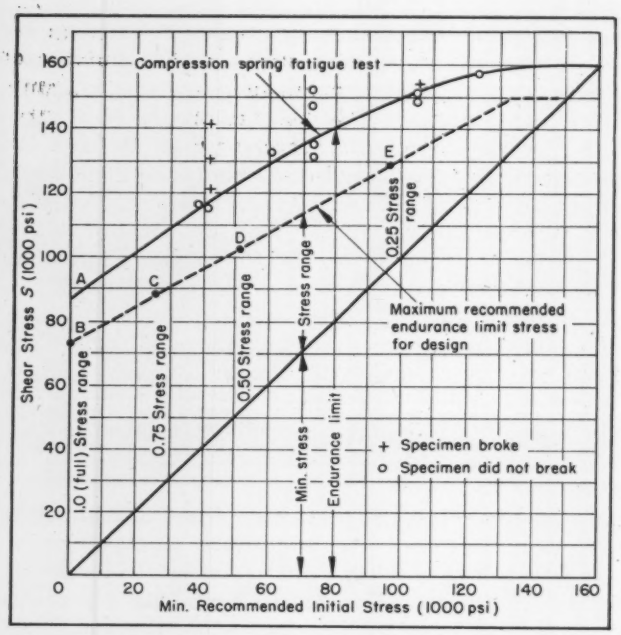


Fig. 7—Maximum recommended endurance limit stress for design versus minimum recommended initial stress, based on compression spring fatigue tests on 0.022-inch music wire at 10 million cycles or infinite life. Chart illustrates the continuous decrease in allowable stress range as maximum stress increases

range = 2.0). Allowable shearing stresses required in design can be derived, by the application of suitable correlation factors, from the bending stresses in *Fig.* 4.

In obtaining these correlation factors, enough complete fatigue tests were run on actual springs, as well as rotating-beam tests on wire alone, to insure reliability. When the two sets of results were compared, the correlation between them became quite evident.

The development of recommended maximum shear stresses for design from actual fatigue tests on springs is shown in *Fig.* 5. The upper curve represents the stress-life relation for 0.022-inch music wire at 1.0 stress range and is based on fatigue testing of compression springs (this curve is therefore not identical with the 0.022-inch music wire rotating beam fatigue curve in *Fig.* 4.) The lower dotted curve gives recommended design stresses developed from the compression-spring fatigue test. A safety margin of approximately 13 per cent accounts for a recommend endurance limit stress of 73,000 psi, as compared to the test value of 84,000 psi. The larger difference between recommended design stresses and fatigue-test results at lower life cycles includes consideration of several other effects in addition to a safety factor. It is known that test results tend to be abnormally high at high stresses because residual stresses exist which increase the apparent yield point of the material. To insure safe operation, the recommended design stress at 10^3 cycles has been fixed at the actual yield point of the material.

The design stresses in *Fig.* 6 are based on additional fatigue tests on compression springs coiled from 0.022-inch music wire. The curve for 1.0 stress range is equivalent to the dotted curve in *Fig.* 5. The remaining three curves for 0.75, 0.50 and 0.25 stress ranges indicate the increase in maximum recommended design stresses as the spring is operated at less severe stress conditions. The increase in endurance limit stress from 73,000 psi at full stress range to 128,000 psi at 0.25 stress range indicates the need for careful attention in selecting maximum design stresses.

The curves in *Fig.* 7 represent continuous change in stress range of 0.022-inch music wire designed for infinite life. Both the curves for the compression-spring fatigue test and maximum recommended endurance limit stress for design are simply extensions of *S-N* curves and present no new data. Thus, for example, Point A on *Fig.* 7 indicates a maximum shear stress of 85,000 psi for full stress range is equivalent to Point A on *Fig.* 5. In the same manner Points B, C, D and E in *Figs.* 6 and 7 are the maximum stresses at 1.0, 0.75, 0.50 and 0.25 stress ranges, respectively. In *Fig.* 7, for example, it is recommended that for infinite life at 0.50 stress range the spring be designed to operate within working stresses

(*Concluded on Page* 190)

PRODUCTION AND DESIGN

Modern Practices in Manufacture

Improved Producibility Through Extrusion

Strength-weight ratio and quality improvements accompany production time savings with propellers designed for extrusion

DEVELOPMENT of a new mass-production method for hot extruding one-piece, hollow-steel propeller blades for high-speed combat and commercial aircraft makes possible spectacular savings in strategic materials, skilled manpower, costly machining operations, floor space required for manufacturing, and tools. Improved producibility of the extruded blade is accompanied by a marked increase in blade quality and strength-weight ratio. The tough, homogeneous structure of the extruded steel provides greater resistance to the more severe stresses to which propellers for higher horsepower piston and turboprop engines, now in production or being designed, will be subjected.

While extrusion—the art of shaping metal in a continuous form by forcing it through a die—has been practiced by industry for over a quarter of a century, use of the basic process has been confined principally to the production of pipe, tubes, bars and other simplified forms except in the lighter and softer metals. When the research program was inaugurated by the Propeller Division of the Curtiss-Wright Corp. in co-operation with the U. S. Air Force, no recorded data were available on the hot extrusion of steel in anything approaching the complex shapes and tapered thickness required in propeller blade manufacture.

From this standing start, Curtiss-Wright and U. S. Air

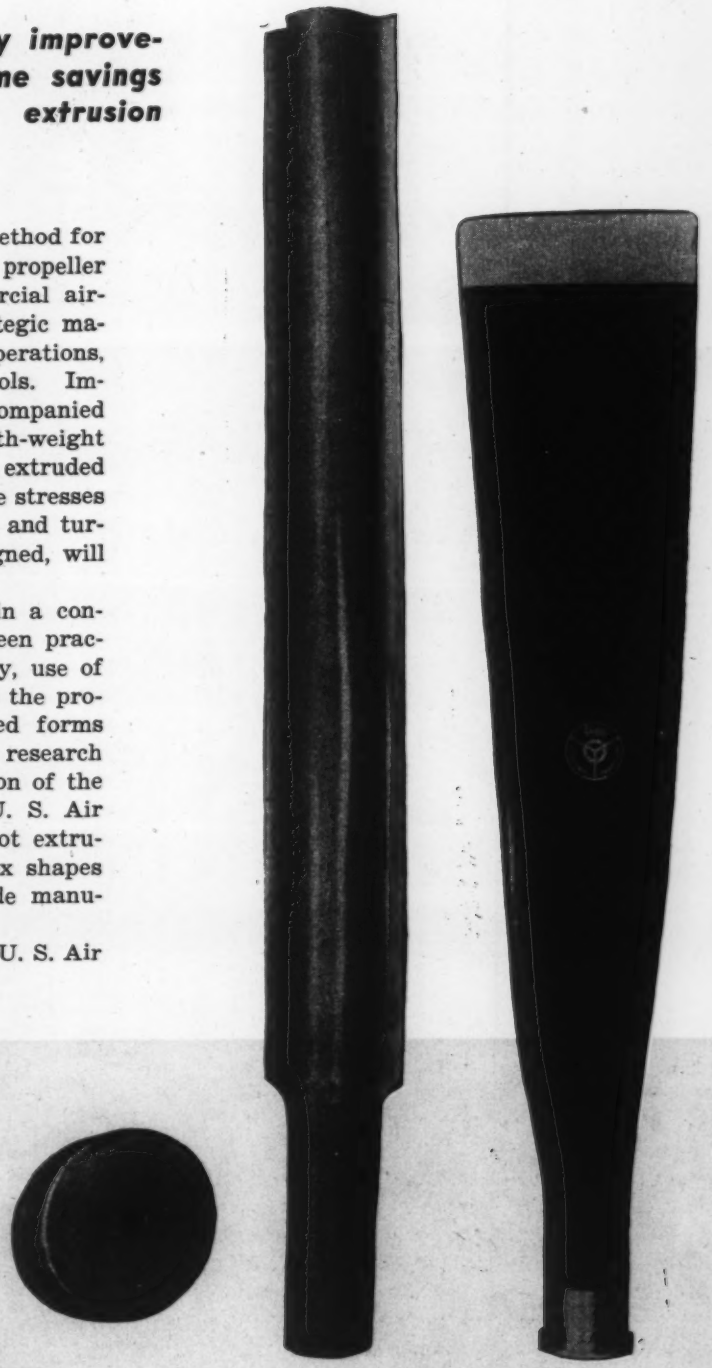


Fig. 1—This 400-pound steel billet is extruded into a flanged tube and taper formed to final shape of a modern propeller blade

Force technicians, with the aid of the metal working industry, perfected in less than two years, the technique of squeezing a white-hot 400-pound chrome-nickel-molybdenum steel billet through appropriate dies with a 5500-ton press to produce a 200-pound, 10-foot propeller blade tube. This process, shown in the following illustrations, is accomplished in three stages as contrasted with present time-consuming methods of welding together, brazing and forming two specially-processed flat plates, weighing 750 pounds before machining, to produce the same size blade.

On the basis of experience gained in the propeller blade development program, those who participated are of the opinion that the new methods have unlimited possibilities in other fields. Listed among items which can be produced by extrusion are landing gear struts, helicopter masts, helicopter or aircraft drive shafts, helicopter main rotor blade spars, gun barrels, tank parts, ship parts, and members for prefabricated structures such as bridges and towers.

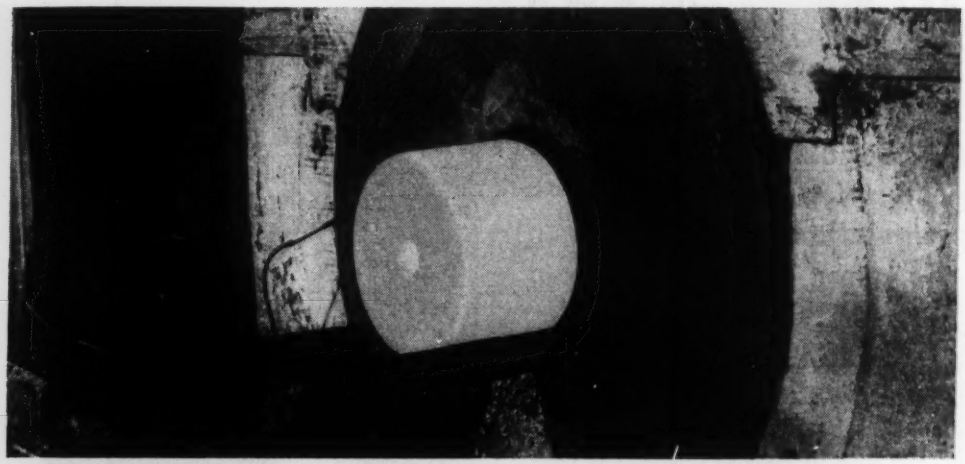


Fig. 2—White-hot billet being inserted in the die container of the 5500-ton extrusion press for the first operation which forms the shank of the finished propeller blade

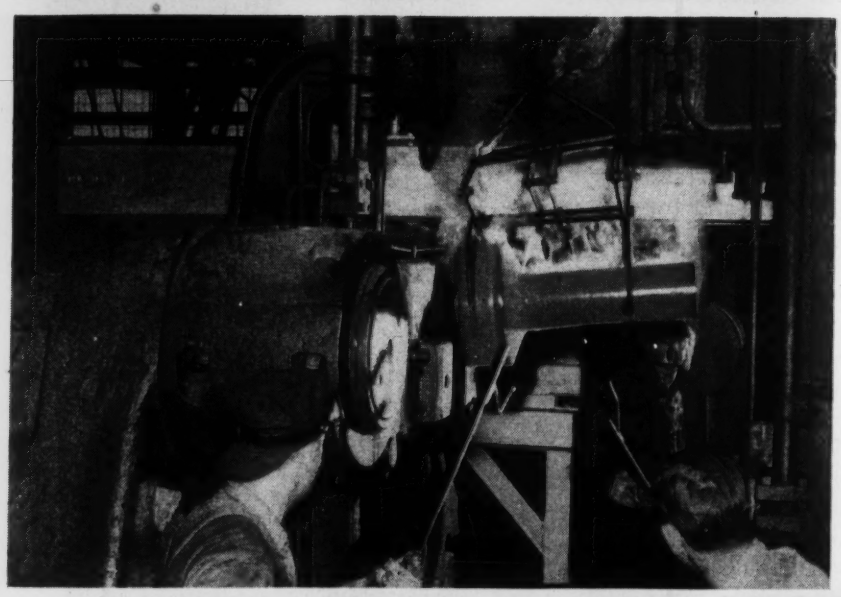


Fig. 3—Reheated after the first extrusion, the partially-formed steel billet is returned to the press for the second operation of the Curtiss-Wright process which expands and tapers the shank section in preparation for the final extrusion of the propeller blade tube

Fig. 4—Below—Shank end first, a white-hot propeller blade tube emerges from the press on the third and final operation

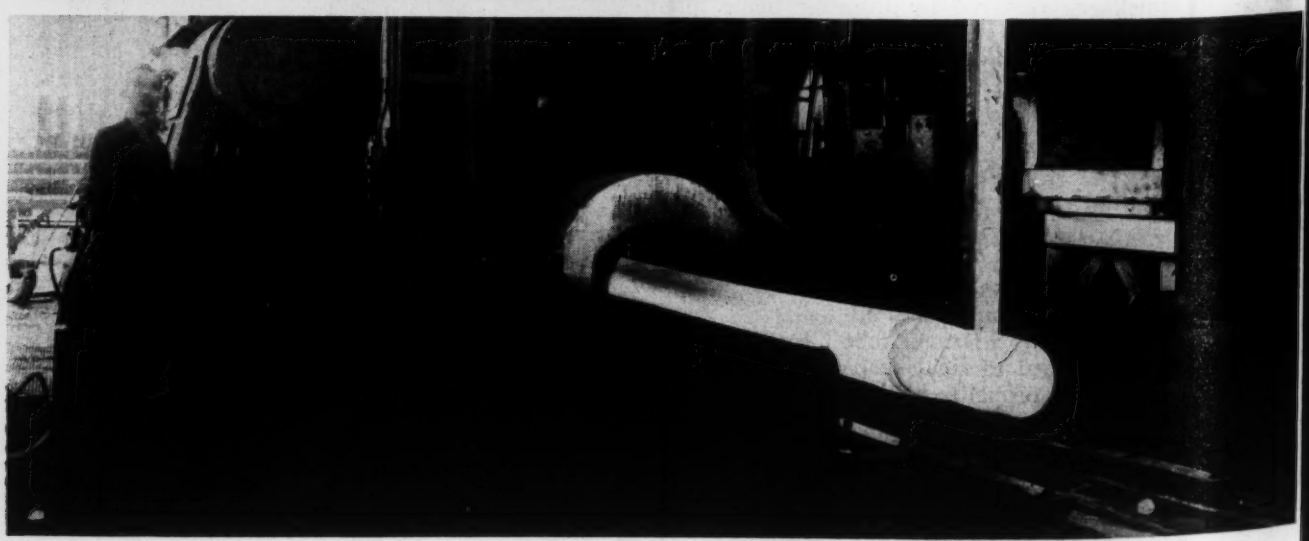


Fig. 5—Before the extruded hollow steel tube is processed into a propeller blade, the tapering wall thickness is carefully measured to make certain that required tolerances are met

Fig. 6—The only major machining operation in the transformation of an extruded tube into a finished propeller blade is the machining of the shank or hub

Fig. 7—Below—Magnaflux inspection of the internal and external surfaces follows the flattening and forming of the extruded steel tube into the shape of the final propeller blade

ELEMENTS OF AUTOMATIC H

Feeding, chuting and orienting parts for assembly

By Charles E. Kraus *President, Kraus Design Inc., Rochester, N. Y.*

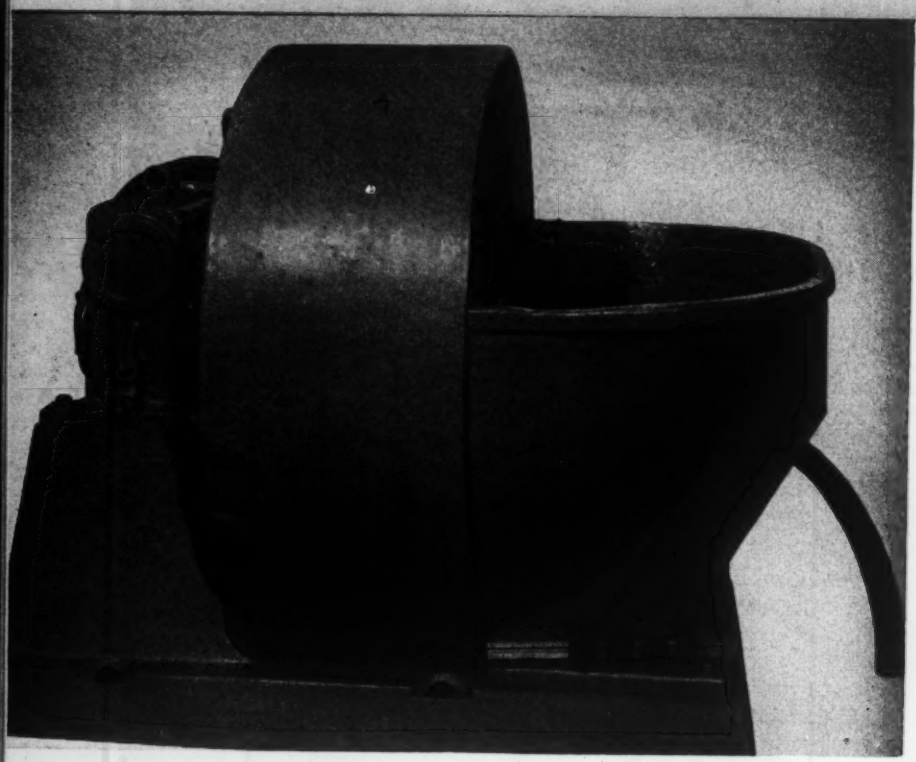


Fig. 1

WITHIN recent years the trend toward automatic handling equipment has received considerable impetus from increased labor demands, and more recently from increased scarcity of workmen. In all branches of industrial activity the tendency toward automation is pronounced, and in some industries the increased use of such equipment is producing what almost may be called a renaissance. Because of this, engineers everywhere will be called upon more and more for the design and development of this type of equipment. The purpose of this article, therefore, is to offer a greater familiarity as to the possibilities of meth-

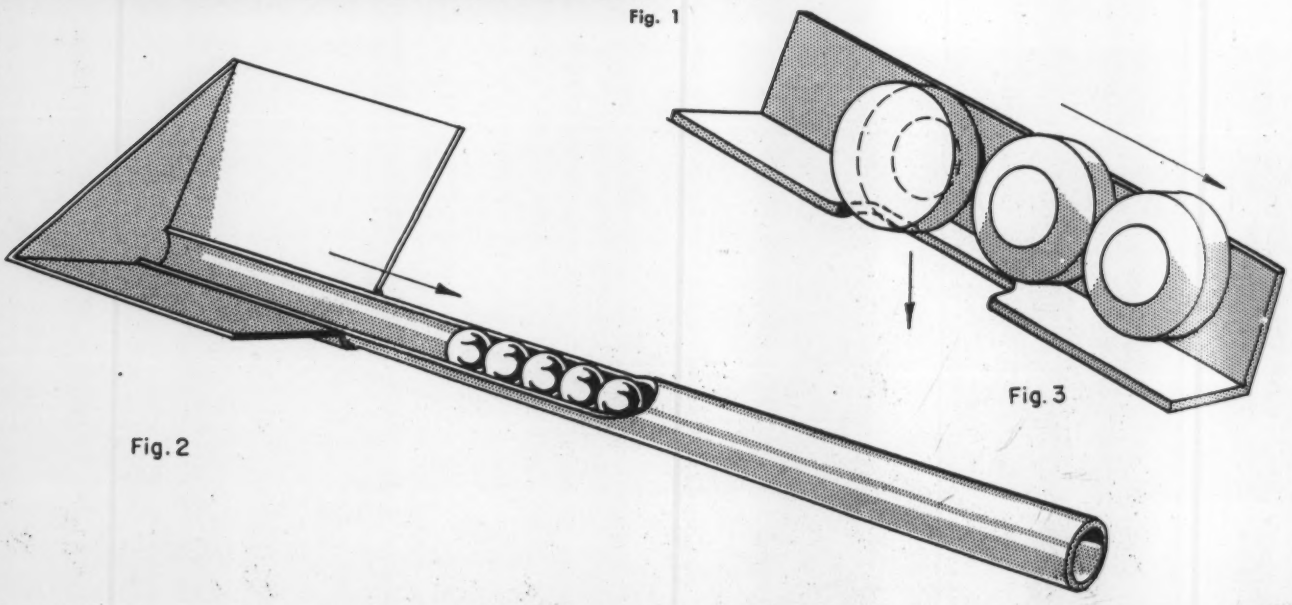


Fig. 2

Fig. 3

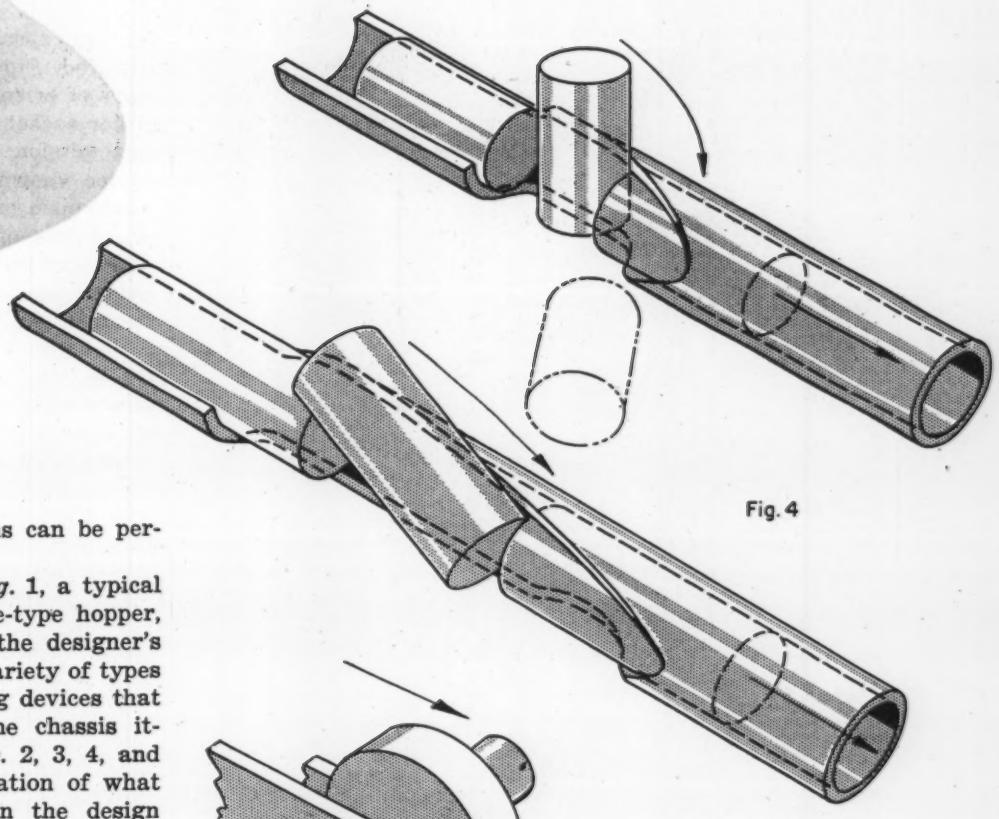


Fig. 4

ods by which operations can be performed automatically.

With reference to *Fig.* 1, a typical installation of a tumble-type hopper, we would like to call the designer's attention to the large variety of types of chuting and orienting devices that can be embodied in the chassis itself. For example, *Figs.* 2, 3, 4, and 5 give a fair representation of what can be accomplished in the design stage, for handling and chuting various parts, with a schematic drawing being shown in *Fig.* 6.

If orientation facilities are not offered by the chute itself it may be necessary to pass the parts through a secondary device which is designed

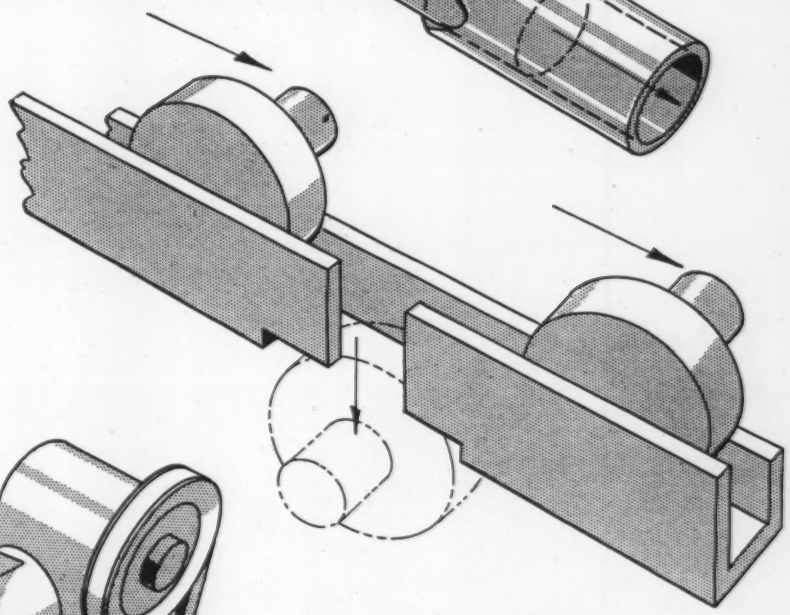


Fig. 5

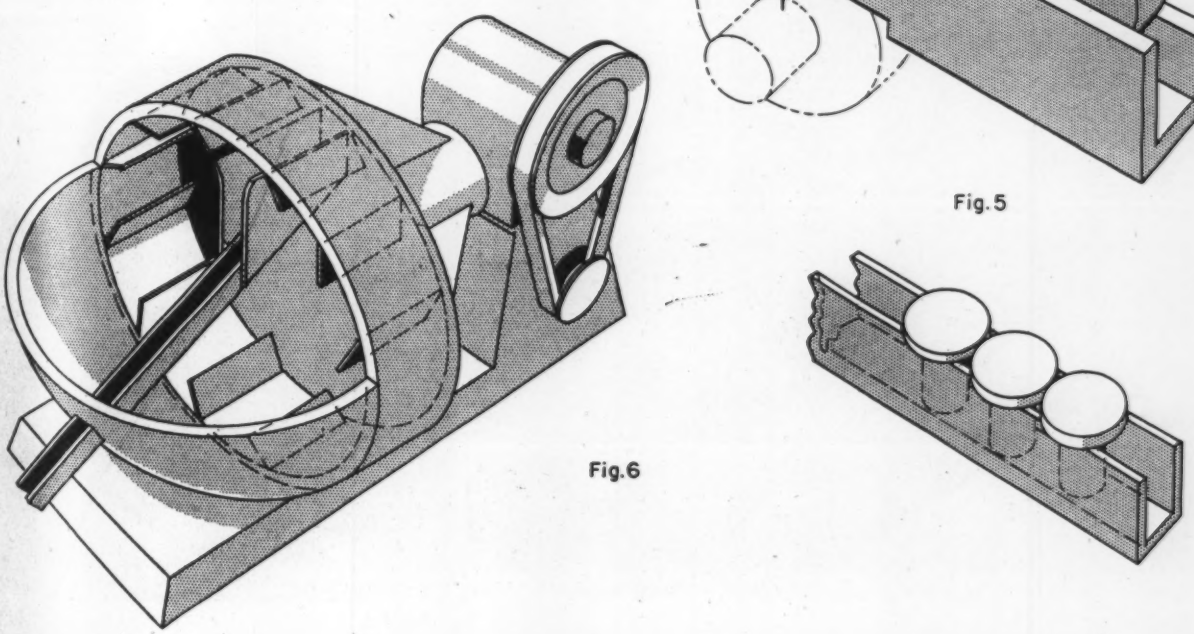


Fig. 6

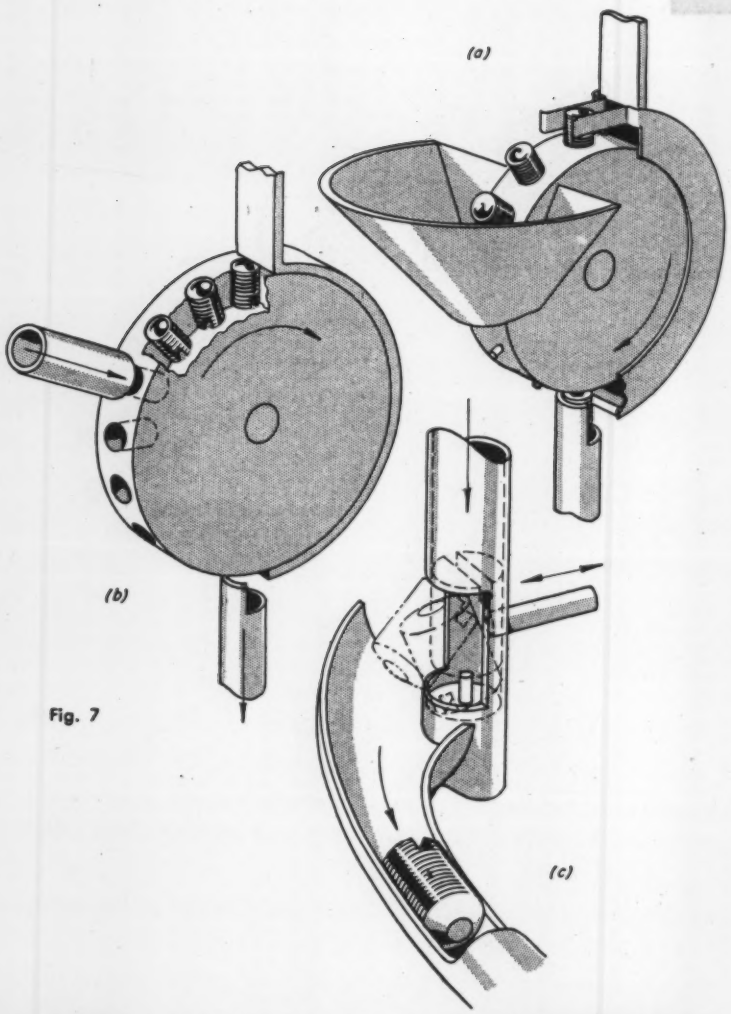


Fig. 7

for the specific orientation that is required. *Fig.* 7 shows three possible ways of orienting headless set-screws, either socket or slotted, with a modified version of element *"b"* of this device shown in *Fig.* 8. This latter mechanism orients a cylindrical piece which has one end rounded and the other end flat; thus all pieces are delivered down a vertical tube with the rounded end leading.

Sometimes the problem arises where the automatic handling of pieces which by reason of size, shape, or material, differ from the conventional. The means for chuting such parts, as a rule, are more complex and this very complexity makes it necessary that such devices be foolproof. An example of a chute specially designed for a unique part may be found incorporated in the hopper shown in *Fig.* 9. This particular chute will convey hook-eyes along a rod, which holds the pieces by the eye opening and delivers them side by side with their points down.

When hoppers, chuting, and orientation devices have been designed to meet all requirements and the necessary metering and inserting mechanisms have been adapted to the particular requirement, these several units can be combined to offer fully automatic operation for a vast range of assembling, machining and pack-

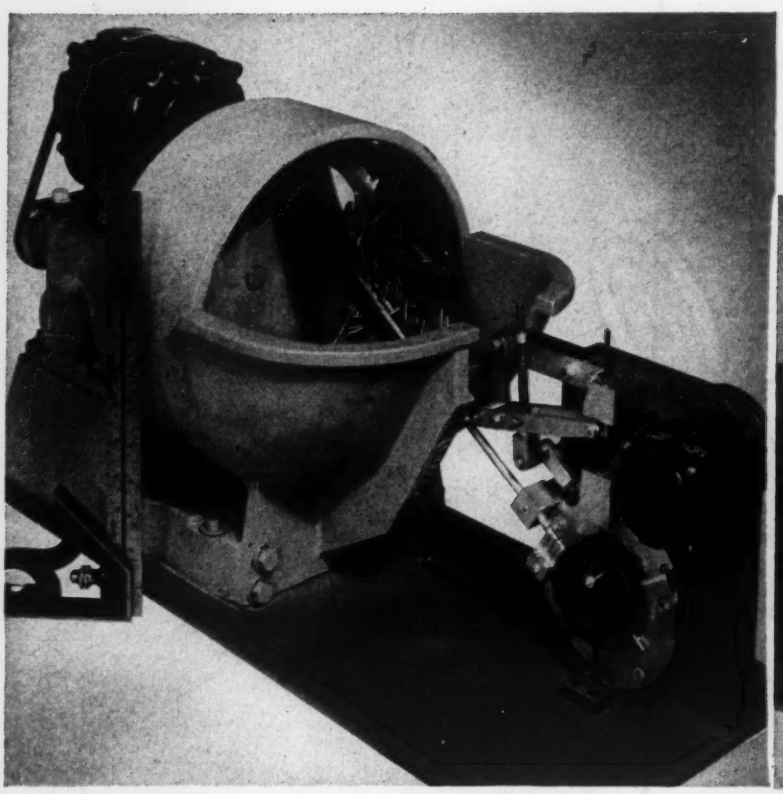


Fig. 8

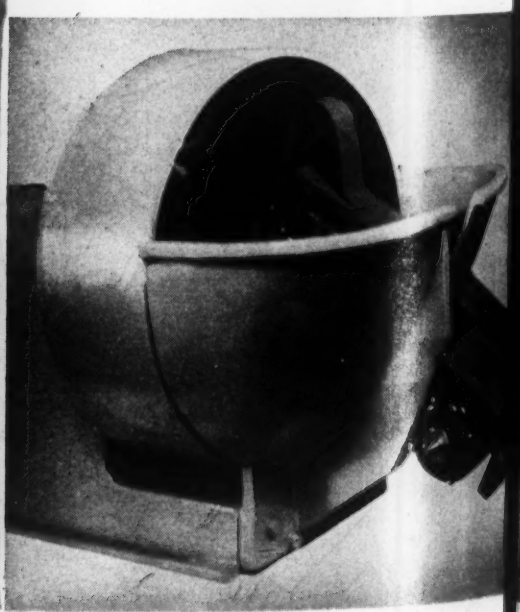


Fig. 9

aging operations. *Fig.* 10, for example, consists of an automatic assembly machine which is fed by two hoppers, one handling optical screws and the other handling optical washers, with the machine itself designed to place the washers on the screws.

Another type of automatic assembly equipment which delivers three different pieces into position and assembles, is shown in *Fig.* 11. In *Fig.* 12 is illustrated a standard welding machine which has an installation of four hoppers (one not visible) which permit automatic handling and positioning of four different pieces.

One of the most common reasons for neglecting the use of automation is the reluctance of an engineer to design and develop a special-purpose machine simply because it has never been done before. In fact, this field offers exceptional challenge to the designer whose technical background is supplemented by a rich supply of imagination and ingenuity.

We have endeavored therefore in this article to show, by a few highlights, how a complex machine is composed essentially of a number of interrelated mechanisms which by themselves are fairly straightforward in design. Inasmuch as many unusual pieces are being handled by automatic means, it is well worth investigation to determine if a particular problem can be solved readily.

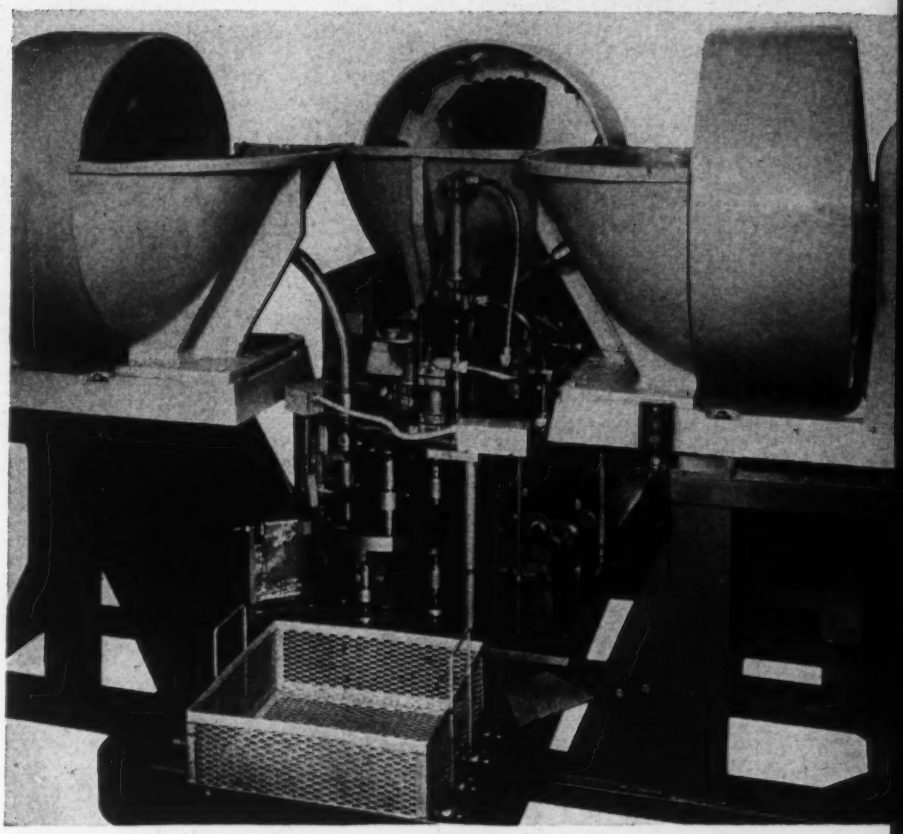


Fig. 11

Fig. 10

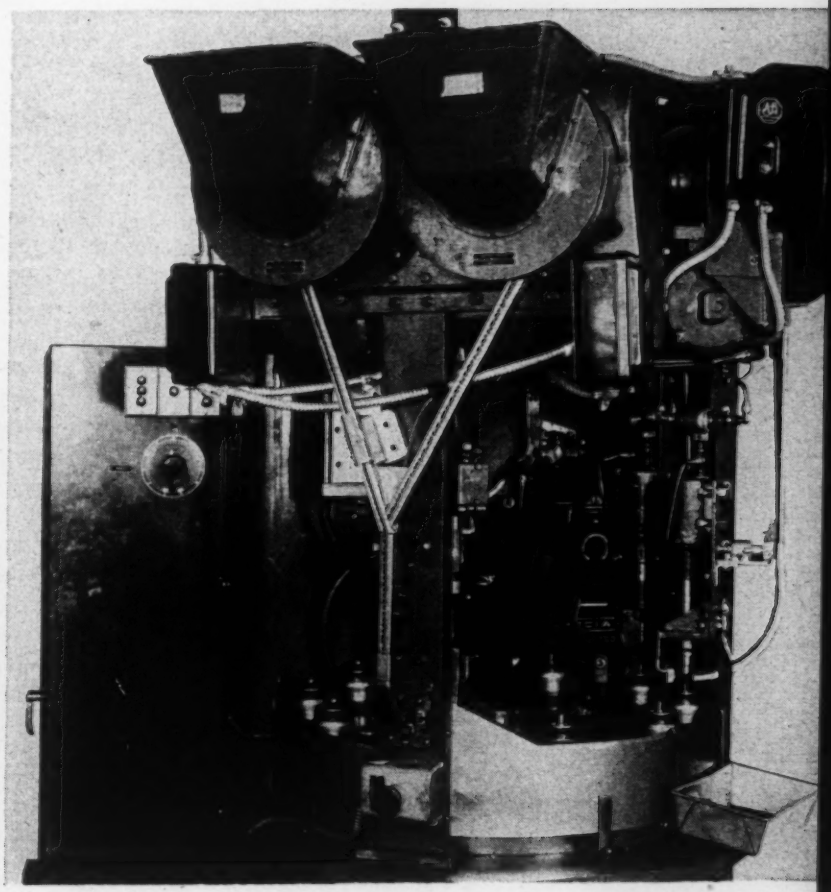
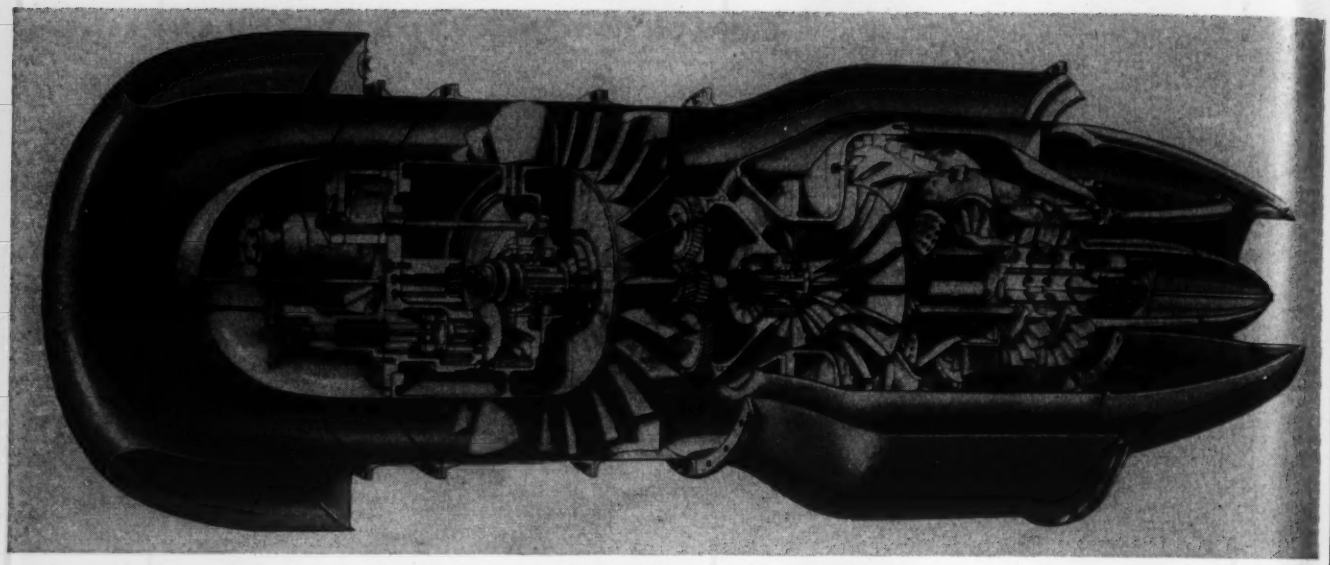


Fig. 12



Ducted Fan Engine Generates High-Speed Air Jet

A HIGH-SPEED jet of air provides the thrust in an unconventional French aircraft engine. The new engine, named the Aspin, employs a gas turbine to drive the high-speed fan, *Fig.* 1. Possessing characteristics midway between a pure turbojet and a turbine driving a conventional propeller (turboprop), the unit has large potential use in medium-size aircraft.

Developed for guided missiles, target planes and aircraft, the new engine ducts the air flow from the multiblade fan back to a jet discharge. Part of the air is diverted to the compressor, combustion chamber and bucket wheels of the gas turbine, from which it emerges as an additional jet. When installed in a four-place aircraft the engine makes a cruising speed of about 300 mph possible, compared with 170 mph for present aircraft of the same type.

Takeoff thrust of 794 pounds is developed at sea level. For a given fuel flow, static thrust is substantially greater than a turbojet's but smaller than a turboprop's. At high flight speeds the situation is reversed, with the ducted fan developing more thrust than the turboprop and somewhat less than the pure turbojet. *Fig.* 2 shows thrust and fuel consumption at various altitudes and speeds.

Power-to-weight ratio is much higher than that obtainable in aircraft piston engines, resulting in increased lifting capacity. Gasoline, diesel fuel, kerosene or alcohol can be used for fuel, with a consumption of 0.55 pounds per hour per pound of thrust on sea-level takeoff. Critical materials such as columbium, cobalt and tungsten, commonly associated with present-day turbines, are not required in the new French engine.

The Aspin is one of nine gas turbines for which Continental Motors Corp. has purchased United States manufacturing rights. Developed by Societe Turbomeca under sponsorship of the French Air Ministry, the nine turbines have various methods of power transmission, including transmission through a shaft, by means of compressed air, by conventional jet reaction, or by the ducted fan system.

Fig. 1—Top—Aspin ducted-fan powerplant. Air flow from a multiblade fan is ducted back to a jet discharge

Fig. 2—Below—Flight characteristics of the Aspin engine, showing thrust and fuel consumption

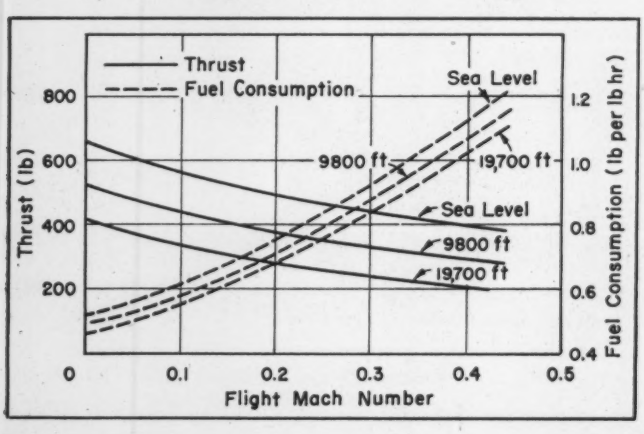
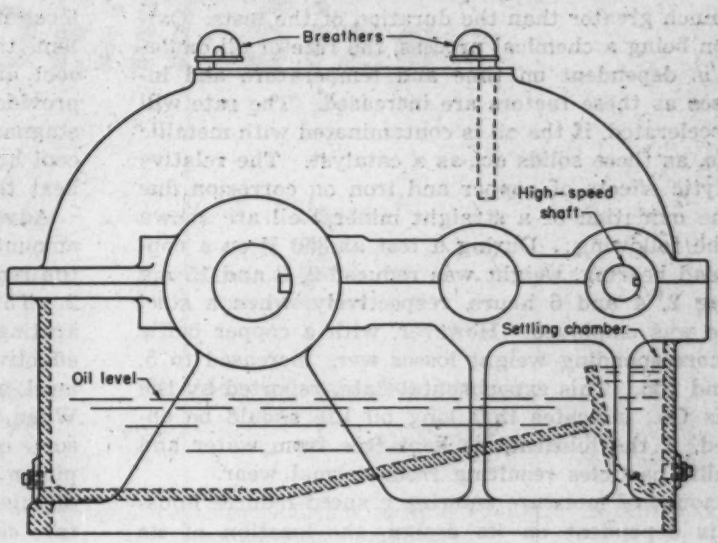


Fig. 1—Inner race of roller bearing damaged by oxidized lubricant. Water condensation accelerated the corrosive action of the oil

Fig. 2—Gear case incorporating the double-breather which greatly reduces condensation on the housing walls. Also a settling chamber below the high-speed shaft effectively removes particles from the oil



Double Breather Eliminates Condensation Problems

By Kenneth N. Mills

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WHEN geared speed reducers are operated in areas with nominal amounts of moisture in the atmosphere, water can enter the lubricant by condensation on the inside walls of the housing. The problem is similar to that of condensation in the crankcase of internal combustion engines and the effects are identical, although the time is greater because operating temperatures are lower. Moisture in the lubricant has two adverse effects. If an emulsion with the oil is formed, the film strength of the lubricant is reduced materially and excessive gear wear may result. Condensed moisture promotes oil oxidation and causes the oil to become corrosive. Because the products of oil oxidation are corrosive acids, attack on metal parts may cause excessive rates of wear.

The bearing inner race shown in *Fig.* 1 was destroyed by wear resulting from a badly oxidized oil. In this illustration, the section of the race outside the roller pathway is pitted by corrosion, and the section in the roller pathway is badly worn. This wear was produced by the abrasive products of the corrosive oil combined with the etching action of the corrosive agents in the lubricant.

According to information published by the Texas Co., the neutralization number of oil increases to 1.9

after heating for 120 hours at 205 F when 20 per cent water is present in the oil. The number for the same oil without water present is 0.5. This shows that the corrosiveness of oil increases at a rapid rate when contaminated with water.

While the service temperature of the lubricant used in speed reducers is usually less than that used in these tests, the usual periods between oil changes are much greater than the duration of the tests. Oxidation being a chemical process, the rate of oil oxidation is dependent on time and temperature and increases as these factors are increased. The rate will be accelerated, if the oil is contaminated with metallic solids, as these solids act as a catalyst. The relative catalytic effects of copper and iron on corrosion due to the oxidation of a straight mineral oil are shown by the following: During a test at 350 F on a copper-lead bearing, weight was reduced 2, 3 and 15 mg during 2, 4 and 6 hours, respectively, when a steel baffle was employed. However, with a copper baffle the corresponding weight losses were increased to 5, 75 and 155. This experimental data, reported by the Texas Co., indicates that long oil life should be obtained, if the lubricant is kept free from water and metallic particles resulting from normal wear.

Amount of moisture entering a speed-reducer housing is dependent on its design, the location of its breather and the magnitude of the load on the reducer. The normal breathing action of the reducer provides a slow but continuous change of air inside the reducer. The heat developed by the gears raises the temperature of the air adjacent to the gears. This warm moist air, contacting the cooler housing walls, is chilled and condenses on the walls. This undesirable condensation, however, can be prevented by proper design which would assure a higher rate of air circulation.

The basic nature of air circulation in a speed reducer can be used to reduce the rate of condensation. The breather system shown in *Fig.* 2 takes advantage of this principle, and has effected a material reduction in the rate of condensation in speed reducers of this type. In this reducer, two breathers are utilized. One is fitted with a tail pipe extending into the reducer housing, and the other opens into the uppermost portion of the housing. In this breathing system, the warm air flows out through the latter and cool air enters through the former breather. This provides a circulating path for the air, eliminating stagnant areas of contact between warm air and the cool housing wall and reducing the time available for heat transfer and condensation.

Adverse effects of metallic particles and small amounts of condensation can be reduced by fitting the reducer with a settling chamber as shown in *Fig.* 2. This chamber can be formed by a cast wall separating the main reservoir into two sections. To be effective, the wall must extend above the working oil level and be located under the high speed pinion. When the settling chamber is located in this manner, some of the oil thrown off by the high speed gear and pinion will fall into it. As the oil in the lower portion of this chamber is static, metallic particles and moisture carried in the oil will settle in this chamber and their adverse effects on the lubricant will be materially reduced.

Operating data on the relative performance of gear reducers with single breathers and with double breathers indicate that, in atmospheres where the single breather would accumulate about one quart of water condensation a month, the double breather model would have no appreciable condensation. In a few cases, a tablespoon of condensation accumulated in three months of operation.

Hypersonic Wind Tunnel Gives Mach 10

SPEEDS of more than ten times the velocity of sound are being obtained in the recently completed hypersonic wind tunnel on the campus at the California Institute of Technology, Pasadena, California. Powered principally by General Electric motors, the tunnel was designed and built for the Institute and the Army Ordnance Department to provide vitally needed information for use in the design of future missiles at speeds well above those of present day rockets and missiles.

The new tunnel has been operated at higher than Mach 10. The test section, in which models are mounted, is 5 by 5 inches, although the entire tunnel has an over-all length of four feet. This includes a region of acceleration downstream from the nozzle throat, the test section, and the diffuser section, where the process of slowing down the air takes place.

To accelerate in the expansion section, the air must pass through a slot in the throat of a specially designed steel alloy nozzle. The height of the slot depends on the Mach number desired. Thus, at a speed of Mach 10, air at tremendous pressure blasts through a tiny slit less than 0.005 inch high, or approximately the thickness of a sheet of paper. When the air suddenly expands into the test section, the temperature drops to about minus 430 F, while the pressure drops to about one millimeter of mercury, or 1/1000 of normal atmospheric pressure.

Air, at pressures as high as 1000 psi, is provided by rotary vane and double-acting reciprocating type compressors. The piping arrangement of the compressors can be varied by a system of valves to provide series or parallel compression. Two 150-hp, 600-rpm motors drive eight rotary compressors, four in tandem to each motor. One 200-hp, 600-rpm motor and one 75-hp, 600-rpm motor each drive two more rotary compressors mounted in tandem. Two 100-hp, 1180-rpm induction motors are belt connected to drive the remaining two compressors.

Nomograms Aid Selection of Tap-Drill Size

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IN THE design of machine elements embodying drilled and tapped holes, the tap-drill size specified affects the ease and cost of production. Selection of tap-drill size should be based upon a percentage of the full-thread engagement, and varies with the length of tapping, the material, and the required strength of the fastening. The optimum percentage engagement is that which assures a secure fastening with minimum removal of metal by the tap.

The four charts on the succeeding pages give tap-drill sizes for 50 to 83 1/3 per cent engagement. For major thread diameters ranging from No. 0 (0.060-inch) to 4 inches, the nomograms apply only to the Unified and American thread forms. Standard drill sizes are given on the charts according to the fractional, number and letter systems against continuous inch decimal scales.

The percentage of thread engagement is based on the height, h, of the original American National thread form. That is, where H = height of the V-thread, p = pitch, and n = threads per inch,

$$h = \frac{3}{4} H = 0.64952\, p = \frac{0.64952}{n}$$

The maximum height of an internal thread in the Unified and American thread form, as shown in the accompanying illustration, is

$$h = \frac{5}{8} H = 0.54127\, p = \frac{0.54127}{n}$$

Therefore, the maximum percentage of engagement of Unified and American threads is $\frac{5}{8} \div \frac{3}{4} = 83\ 1/3$ per cent.

In any thread pair, the actual height is $(D - K)/2$, where D = major diameter of the external thread and K = minor diameter of the internal thread. The percentage, T, of thread engagement is then:

$$T = \frac{100n(D - K)}{2\ (0.64952)} = 77n(D - K)$$

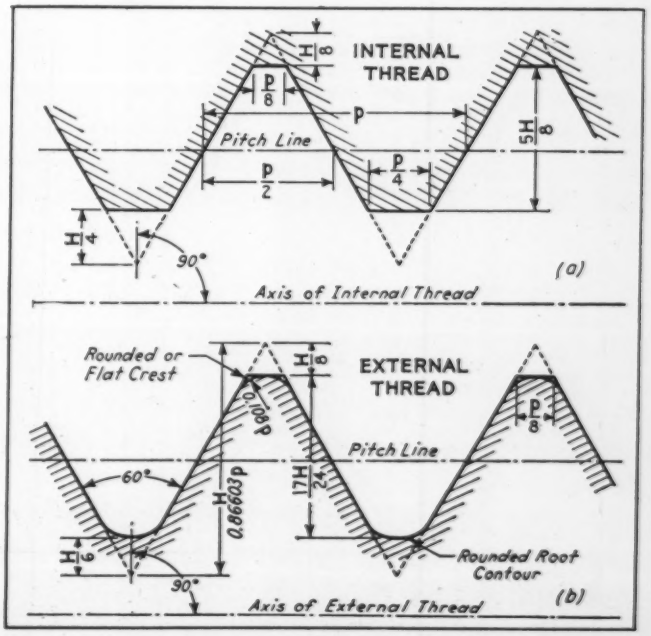
Transposed for convenient calculation of tap-drill size (K), this relationship becomes

$$K = D - \frac{T}{77n}$$

A two-step solution of this equation is provided by the accompanying nomograms.

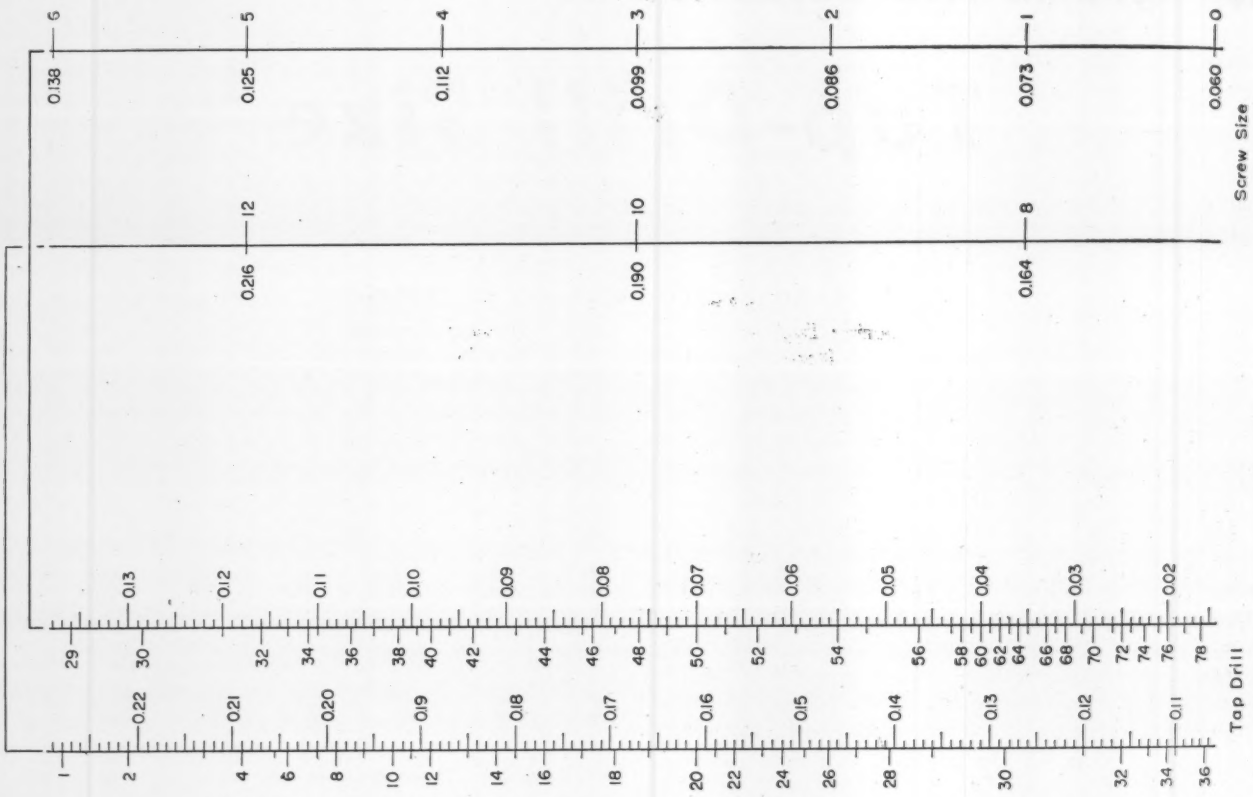
EXAMPLE: Determine tap-drill diameter for No. 5-44-NF with 70 per cent engagement. This size falls within the range of the first chart. Project a line from 70 on the percentage engagement scale through 44 on the threads-per-inch scale to the unmarked scale. By straight line, join this latter point to the No. 5 point on the right-hand screw-size scale. The answer is given on the right-hand tap-drill scale: 0.1043-inch or No. 37 drill (0.104). Note, correspondingly, that if the screw size falls on the left-hand scale, the solution is given on the left-hand tap-drill scale.

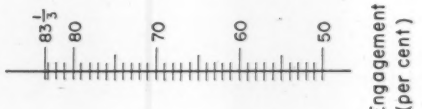
Proportions of Unified and American thread form

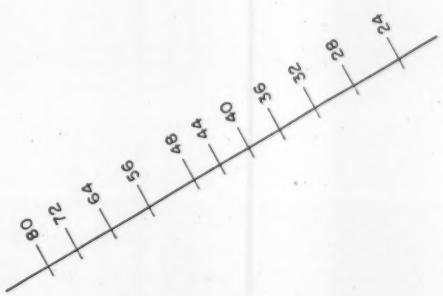


* Now serving with U. S. Army.

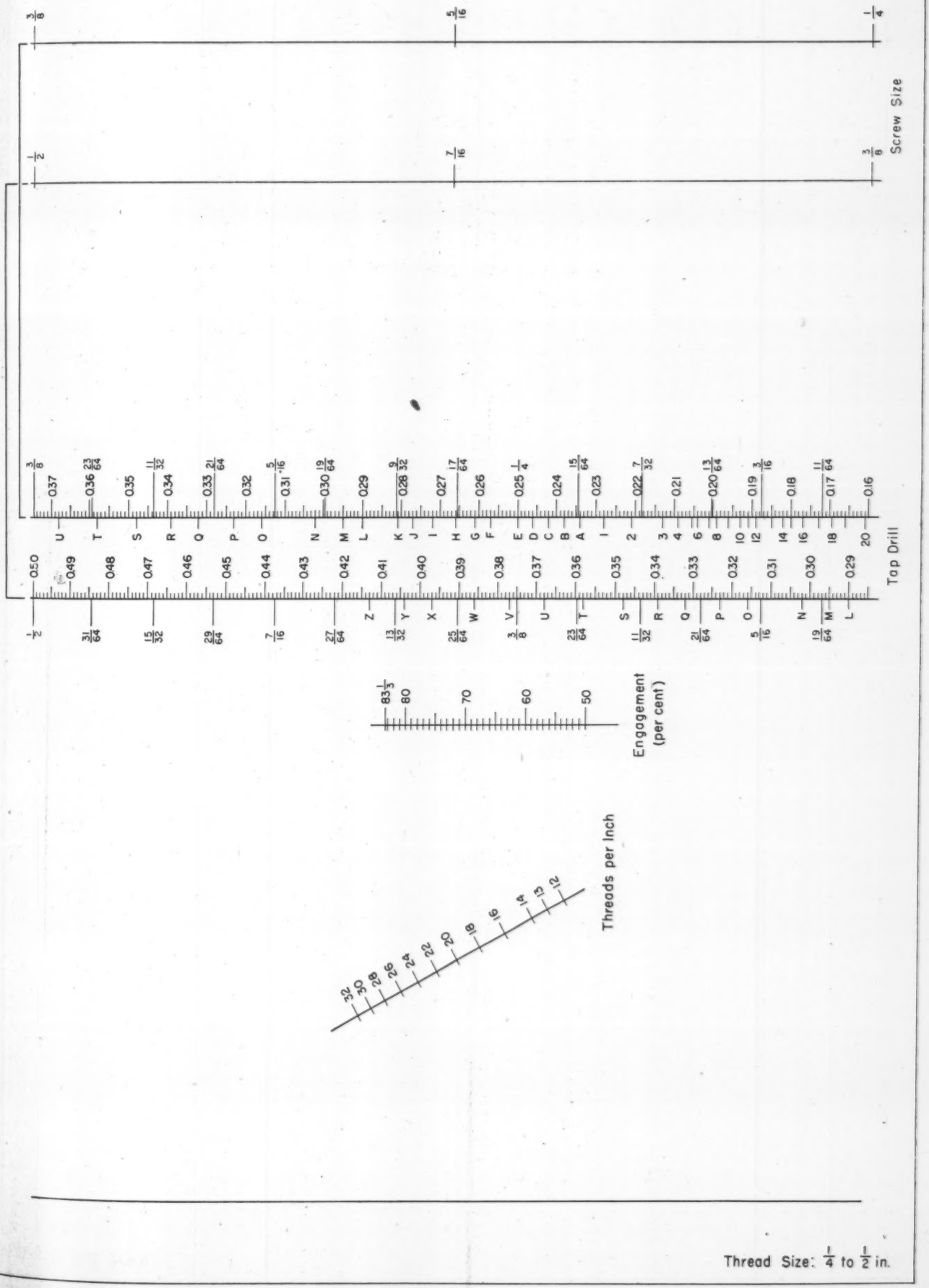
Data Sheet







Thread Size: No. 0 (0.060 in.) to No. 12 (0.216 in.)


Screw Size
Top Drill
Engagement (per cent)
Threads per inch
Thread Size: 1/4 to 1/2 in.

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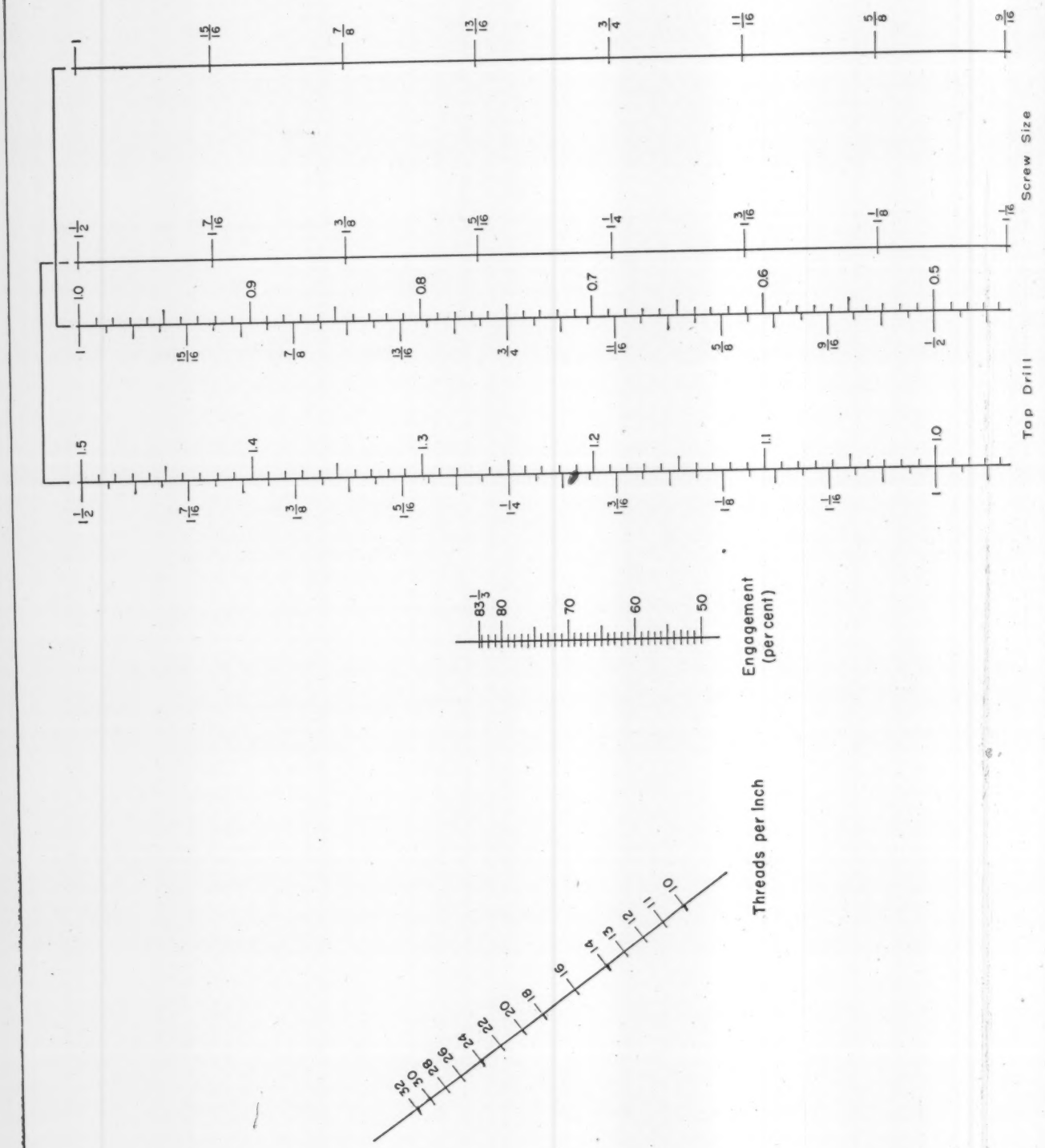
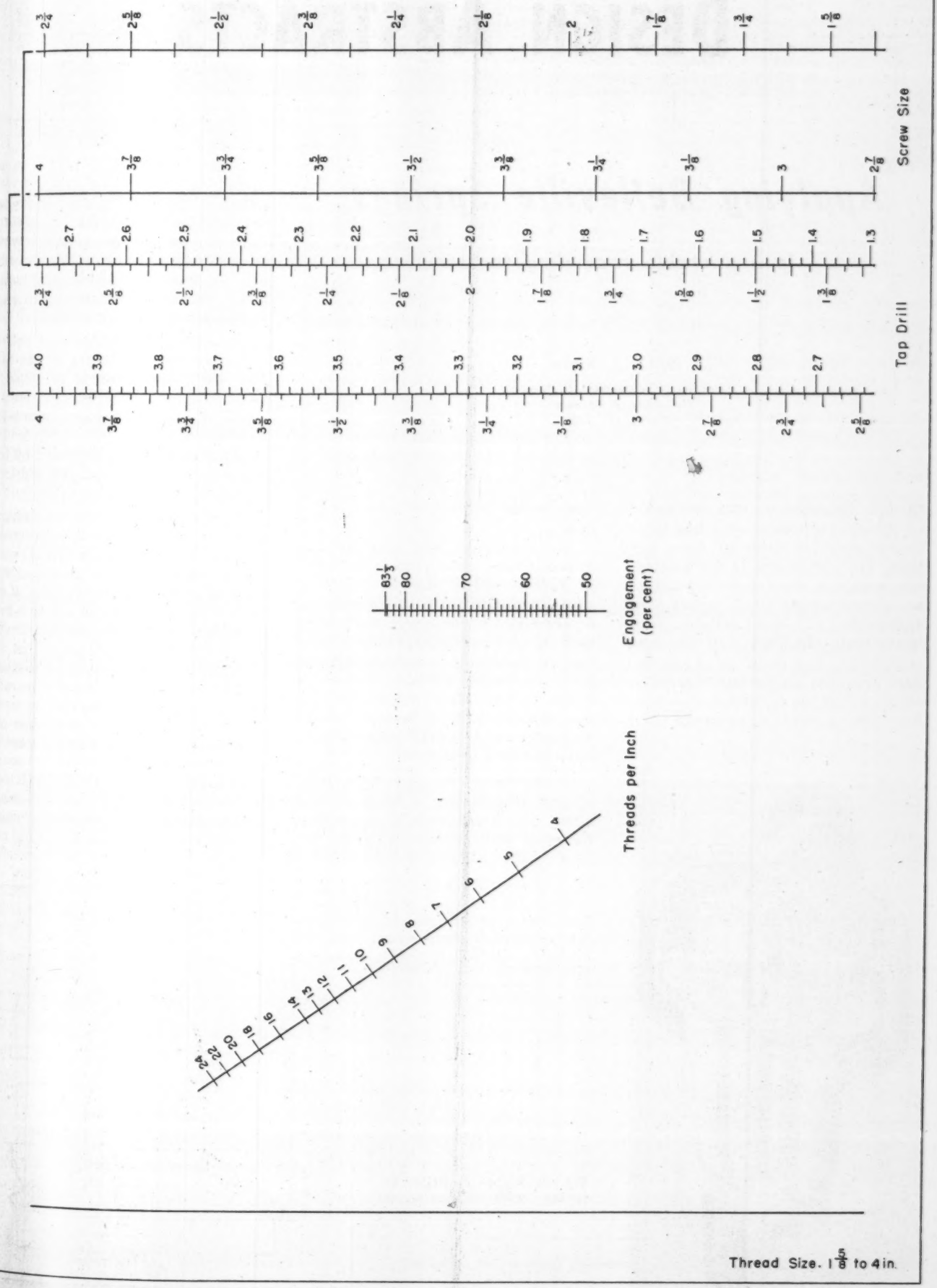


Thread Size: $\frac{9}{16}$ to $1\frac{1}{2}$ in.

Screw Threads



Thread Size. $1\frac{5}{8}$ to 4 in.

DESIGN ABSTRACTS

Applying Belleville Springs

. . . in a portable recording tensiometer

By J. J. Ryan

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THE tensiometer was developed for the purpose of recording large impact loads in units of force and time. The instrument is for portable use, weighing about 6 lb and having an overall length of 9 inches. The application of load deflects very heavy plate (Belleville) springs with subsequent movement of a central post. A scriber on the post marks the amplitude of the deflection on a moving film. A friction governor on a clock motor controls the speed of the film.

The instrument will measure the inertia forces, with respect to time, of falling bodies stopped suddenly while in motion, as in the opening of a parachute. It will also measure live-load forces in structures and is useful in measuring suddenly applied loads on cables used on cranes or hoists to lift heavy weights, or for the measurement of tractive effort and other forces where dynamic conditions of loading exist.

DESCRIPTION: The instrument case, of cast magnesium, is made in two sizes to accommodate maximum forces of 8000 lb and 16,000 lb. Internal dimensions of the cases are approximately the same for the five different ranges of springs which were developed. A cutaway drawing, *Fig.* 1, shows the assembled instrument with all the component parts in position.

The upper pin connector is held by lug projections on the top of the case. The lower connector is attached to a central post. The central post is guided by bearings above and below a stack of dished-plate (Belleville) springs which are compressed by tensile forces applied on the pin connectors.

A clockwork mechanism with a governor drives a take-up spool which draws a clear-base film past a scribing surface. About 15 inches of film may be reeled for one winding of the clock in a time from 30 sec to 4 min, depending upon the setting of the governor. Three styli record on the film. These styli consist of scribing needles mounted on flexible parallel cantilever springs. The middle stylus is connected to the central post and records the vertical displacement of the springs. The lower stylus draws a base line. The upper stylus is connected to a spring-mounted mass, which when displaced by a clock-driven cam, produces a timing rec-

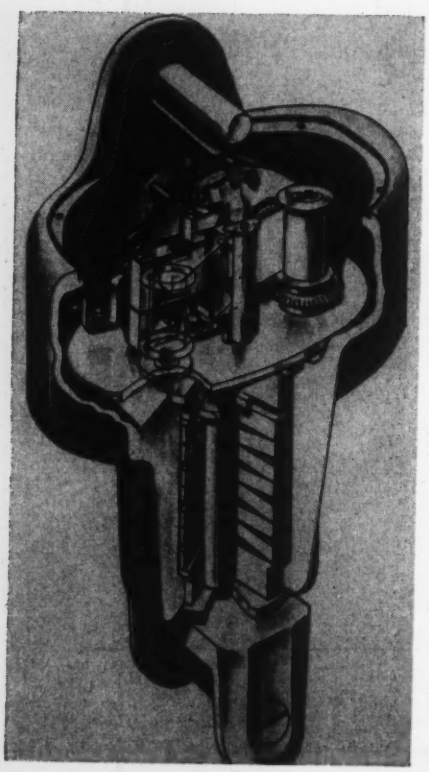


Fig. 1—Left—Cutaway view of Ryan recording tensiometer showing stack of Belleville springs

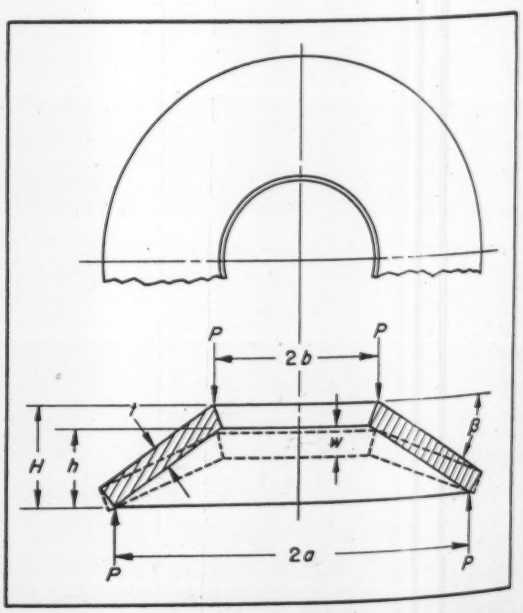


Fig. 2—Right—A Belleville spring with nomenclature

Table 1—Comparative Test and Calculated Deflections of Springs

No.	Max. Load (lb)	Thickness (in.)	Number in Stack	Initial Cone Height (in.)	Calculated 1 Poisson's Flat-Disk Formula (in./1000 lb)	Calculated 2 Almen and Laszlo Formula (in./1000 lb)	Calculated 3 Circular-Ring Formula (in./1000 lb)	Test 4 Stack (in./1000 lb)	Test 5 Single Spring (in./1000 lb)	6 Ratio Calculated to Test (col. 2/col. 4) (col. 2/col. 4)
1	5000	0.1674	9	0.0270	0.01554	0.0439	0.0468	0.040	0.00444	1.10
2	6000	0.1865	9	0.03225	0.0330	0.0313	0.0338	0.030	0.00333	1.04
3	9000	0.21875	7	0.03125	0.0159	0.0150	0.01643	0.0147	0.00210	1.02
4	12000	0.250	7	0.03125	0.0107	0.0101	0.01103	0.010	0.00143	1.01
5	16000	0.281	7	0.03125	0.00750	0.0073	0.00779	0.008	0.00114	0.91

ord as a result of its free vibration.

To prevent binding of the dished-plate springs on the central post and to preserve alignment, flat strips of thin beryllium-copper spring stock are inserted between the post and the plates in the clearance space. The lower nut on the central post is tightened to maintain an initial compression on the plate springs.

The high spring constant, combined with compactness in the axis of loading, makes the Belleville spring applicable for instrument work. However, it was necessary to determine by test if an approximately straight-line relationship of applied load to deflection could be obtained.

SPRINGS: Belleville springs consist essentially of annular disks of constant thickness with an initial cone, as shown in *Fig.* 2. By suitable variation of the ratio of the initial cone height to the disk thickness, h/t, it is possible to obtain load-deflection curves of many different shapes,[1] as indicated in *Fig.* 3. Such a shape as curve A with $h/t = 2.0$ is desirable when a snap-acting device is being designed.

When h/t is about 1.5, the springs known as the constant-load type, curve B, show a considerable range of deflection within which the load is practically constant. This characteristic is highly desirable in many applications—for example, the loading of a gasket with a constant force.

Curve C is a typical load-deflection curve for the initially flat disk spring. We may consider it as a particular type of Belleville spring, with $h/t = 0$. This load-deflection curve is nearly linear for very small deflections, although the curve is concave upward for larger deflections. An intermediate ratio of cone height to thickness, as suggested between curves C and D, *Fig.* 3*a*, may be expected to give a straight-line load deflection for small deflections in the region shown in *Fig.* 3*b*.

In this paper are described tests of ratios h/t, cone height to thickness, between 0.11 and 0.17, which were found to be satisfactory for instrument work where linearity is required as well as a high spring constant combined with compactness in the axis of loading. The deflection curves are linear within normal limits, but tend to be concave upward.

CALCULATION METHODS: Application of the mathematical theory of elasticity to dished-plate springs may be approached in several ways. It may be demonstrated that the deflection of initially flat-plate springs is directly proportional to the load when the deflection is small in comparison to the plate thickness.

Poisson's flat-disk formula[2] for small deflections is given by S. Timoshenko as follows:

$$P = \frac{wEt^3}{K_1 a^2} \qquad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where E is Young's modulus and K_1 is a constant of the plate dimensions, calculated by Wahl and Lobo[3] and tabulated in Reference 4. Since all the dished-plate springs had the same inside and outside radii of 0.755/2 and 1.99/2 inch, the ratio $a/b = 2.64$ would have a value for K_1 of 0.714. Calculations of deflections with this equation are given in TABLE 1, column 1.

If deflections are no longer small in comparison to thickness, analysis of problems of this nature must be extended to include the strain of the middle plane of the spring plate. In this case the exact theory is quite complicated, and deflection is no longer proportional to the load applied.

Exact solutions by the theory of elasticity for the deflections and stresses of Belleville springs are extremely difficult[4]. However, based upon the assumption of rotation of the radial cross sections without distortion, approximate solutions were derived by Almen and Laszlo[5]. These investigators reported tests which indicated that the assumption was satisfactory for practical use. The final results of the derivations, when deflection and conical height are small in comparison with the thickness, can be further simplified to

$$P = \frac{Ewt^3}{M(1-\mu^2)a^2} \qquad \ldots\ldots\ldots\ldots (2)$$

where

$$M = \frac{6}{\pi \log_e \alpha} \frac{(\alpha - 1)^2}{\alpha^2}$$

and $\alpha = b/a$, μ = Poisson's ratio. Again, deflection is directly proportional to the load. Calculations of deflections using the approximate Equa-

[1] References are tabulated at end of abstract.

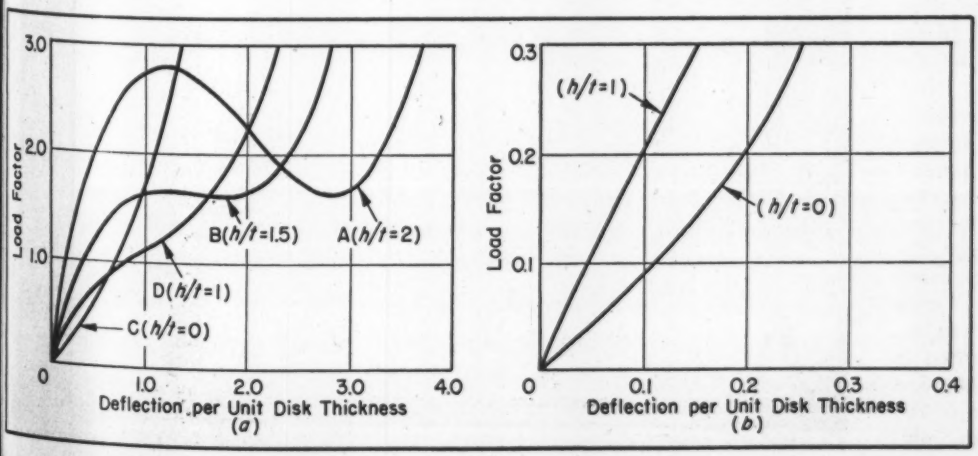
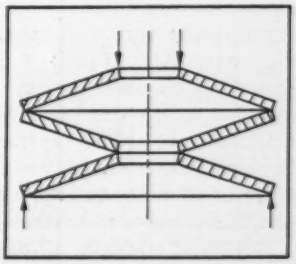


Fig. 3—Left—Characteristics for large deflections, *a*, and small deflections, *b*

Fig. 4—Below—Belleville spring stack



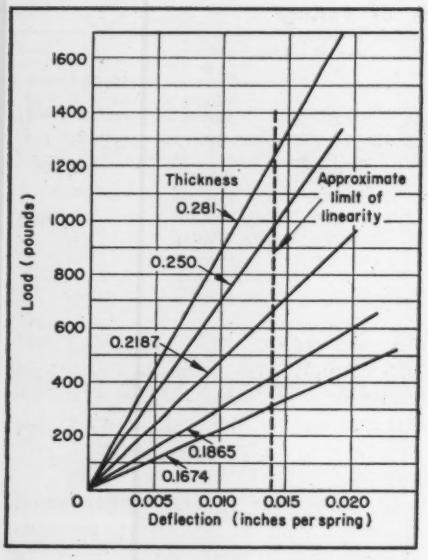


Fig. 5—Load-deflection charts for individual springs

tion 2 are given in the summary TABLE 1, column 2.

Another approximate method of analysis may be applied[6]. Considering the spring as a circular ring twisted by couples uniformly distributed along its center line, and neglecting the effect of the change in the angle β, the following formula may be obtained.

$$P = \frac{wEb}{(a-b)}\left[\frac{t^3}{12(a-b)}\log_e\frac{a}{b} + \beta^2 t\left(\frac{a+b}{2} - \frac{a-b}{\log_e\frac{a}{b}}\right)\right] \quad (3)$$

For large deflections, angle β changes and the approximation becomes less valid. A summary of values obtained by these equations is given in TABLE 1, column 3.

SPRINGS TESTED: Approximately flat dished-plate springs were used in the recording tensiometer. Deflection of each spring was kept within two-thirds of the limiting cone height to obtain an approximately linear load-deflection relation. The springs were stacked in a series of seven or nine, in the manner shown in *Fig.* 4, to enlarge the deflection recorded by the stylus on the moving film. Tensiometers with five different load capacities were constructed. The springs used had the same inside and outside diameters, and thickness of the springs was varied to obtain increasing capacities. TABLE 2 shows the five different spring thicknesses tested, with the individual cone heights and total spring heights. Springs No. 1 and 2 were nested in a series of nine, and springs No. 3, 4 and 5 in a series of seven.

Each dished-plate spring was compressed to a flat position several times in a press before it was assembled to assure its freedom from cracks and to obtain mechanical stability. The maximum calculated stresses under such conditions usually exceeded 300,000 psi, but only in cases of poor heat-treatment did failure occur in the pressing.

TEST RESULTS: A number of loading tests were made with each of the five spring stacks in tensile testing machines. As loads were applied, usually in 1000-lb increments, the tensiometer recording film was moved a short distance by the clock motor. Amplitudes of displacement were measured on a film reader or with a toolmaker's microscope.

The initial slope of the resulting curve is assumed to determine the spring constant of the stack per 1000-lb load and thus the equivalent constant for each spring. The friction of the stack is limited to the upper and lower springs. Deflection for the increasing load is always less than for the decreasing load, although the slopes are usually the same after the first reduction in load has been applied. Calibration for the increasing load is favored in these curves because of its importance in establishing maximum forces. The deviation from the average is not more than plus or minus 5 per cent for different stacks of the same thickness.

A summary of the load-deflection charts for the individual dished-plate springs is given in *Fig.* 5. The maximum test loads deflected the springs to about two-thirds the cone height. The limit of linearity was observed to be approximately one-half the cone height. Plotting deflection constant versus the inverse cube of the individual spring thickness showed that a straight line reflects this relationship with considerable accuracy.

CALCULATIONS VS. TESTS: A tabulation of the calculated deflections of the spring stacks per 1000 lb of load by the three methods outlined in the discussion is presented in TABLE 1, with the results of each calculation given in their respective columns. Test measurements are listed in column 4. The theory as developed by Almen and Laszlo is considered to be the most accurate.

Calculations by Almen and Laszlo were 10 per cent higher for the spring with the least thickness and 9 per cent under for the thickest spring. The calculation average for the series of springs is less than 2 per cent over the test values. According to Almen and Laszlo, and Wahl, the deviation of test from calculated values for springs of this kind may be up to 10 per cent. This error appears to be large, but is made up of a number of factors, each of which may be large in itself. The equations are satisfactory as a guide in design. After the plate springs were assembled and held with initial tension, repetition of the calibration tests in the tensiometer showed no appreciable deviation.

Comparison of Poisson's flat-disk formula and the circular-ring formula with test results indicate slightly higher calculated values, the average ratio of calculated to test constants being 1.07 and 1.10, respectively. Thus the flat-disk formulas and the tables presented by S. Timoshenko,[2, 6] by reason of their simplified approach

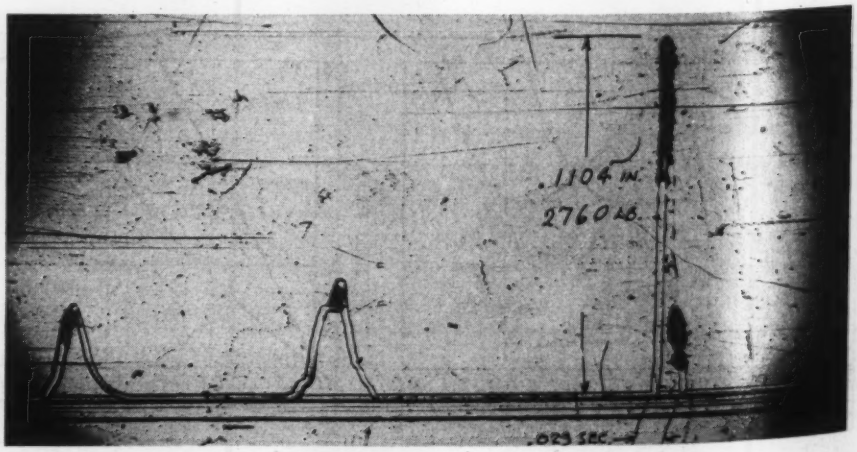
(*Continued on Page* 212)

Table 2—Dimensions of Springs

No.	t	h	H	w/t	h/t
1	0.1674	0.027	0.1944	0.112	0.161
2	0.1865	0.032	0.219	0.107	0.173
3	0.2187	0.031	0.250	0.091	0.143
4	0.250	0.031	0.281	0.080	0.125
5	0.281	0.031	0.312	0.071	0.111

$2a = 1.990$; $2b = 0.755$.

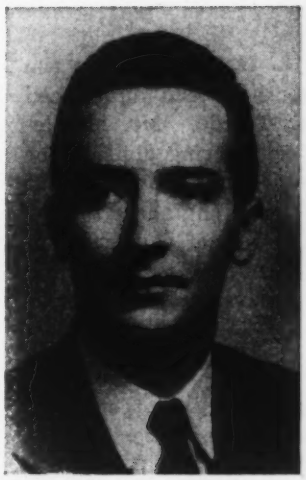
Fig. 6—Sample record of impact test as recorded by tensiometer



MEN OF MACHINES

Director of welding development for the past two years, **L. K. Stringham** has been appointed chief engineer for The Lincoln Electric Co., Cleveland. An electrical engineer and graduate of Cornell University, Mr. Stringham has been associated with the company since 1933. His experience in the engineering department has included experimental research work as well as product development and application. He has worked on the design of welding machines as well as electrodes and fluxes, for both manual and automatic welding. During the last ten years, Mr. Stringham's development work in fused and agglomerated fluxes has been important in extending the uses of the hidden arc welding process. He has also been responsible for the development of equipment for the manual and semi-automatic application of this welding process. He is on the board of directors of The Lincoln Electric Co., a member of the NEMA Navy Committee for the Development of Low Hydrogen Electrodes, a member of AWS-ASTM Committee for Filler Metal, a fellow in the AIEE, a member of the American Welding Society and the electrical honorary society, Eta Kappa Nu.

L. K. Stringham



Elman R. Dunn

♦

New Associate Editor of MACHINE DESIGN, **Elman R. Dunn** is introduced in this month's "Over the Board" columns, Page 4.

♦

George F. Habach

George F. Habach has been appointed executive engineer of the Harrison, N. J., plant of Worthington Pump and Machinery Corp. After graduating from Stevens Institute of Technology with a mechanical engineering degree in 1929, Mr. Habach took the Worthington student training course. He then worked as a designer in development engineering and in centrifugal pump sales and engineering until he was made chief engineer of the Centrifugal Engineering division six years ago. Mr. Habach holds a master's degree in mechanical engineering from the Polytechnic Institute of Brooklyn, where he has been an adjunct professor in mechanical engineering since 1937. He is a member of the ASME and the technical committee of the Hydraulic Institute.

Replacing Mr. Habach, **Everett Schmachtenberg** was appointed chief engineer of the Centrifugal Engineering division. He formerly served as assistant chief engineer of that division. A graduate of the Newark College of Engineering in mechanical engineering, he also took the Worthington student training course. He spent three years in the Research and Development department and was transferred to the Centrifugal Engineering division in 1940. Mr. Schmachtenberg is a member of the compressor committee of the ASME.

Another recent Worthington appointment is that of **H. V. Rasmussen** to the position of executive engineer at the Wellsville, N. Y., plant. Mr. Rasmussen spent a number of years with both the Westinghouse Electric Corp. and DeLaval Steam Turbine Co.

♦

As a result of the retirement of **R. E. B. Sharp** as chief engineer of the S. Morgan Smith Co., York, Pa.,

a number of personnel changes have been made. **Jacob Fisch** was appointed chief engineer, with overall responsibility for all engineering and design. **G. Dugan Johnson** is now chief hydraulic engineer. **Grant H. Voaden** has been appointed assistant chief hydraulic engineer; **V. Chester Smith,** chief mechanical engineer; **Edwin W. Murphy,** head structural engineer; and **Harold I. Knox,** engineering production co-ordinator. Mr. Johnson has been employed by the company since 1939 as a hydraulic engineer. In his new position he will be responsible for hydraulic design and the operation of the hydraulic laboratory. Mr. Sharp is being retained by the company as an engineering consultant.

♦

Associated with the company for 14 years, **A. F. Zamis** was recently appointed chief engineer of Illinois Tool Works, Chicago. He has been placed in charge of engineering, design and development work in connection with the company's line of metal cutting tools.

♦

Promotion of vice president **L. H. Middleton** to the post of director of engineering has been announced by The Electric Auto-Lite Co., Toledo. Mr. Middleton has been in charge of the engineering division for a number of years. At the same time announcement was made of the promotion of three engineers to new posts. **C. R. Boothby** was named chief electrical engineer; **H. D. Wilson,** chief chemical engineer; and **C. C. Cipriana,** chief mechanical development engineer of the engineering division.

♦

Jack D. Peters recently was named chief engineer of Gordon D. Brown and Associates, Beverly Hills, Calif.

♦

The American Society of Mechanical Engineers announced recently that **Thomas Roy Jones,** president of Daystrom Inc., Elizabeth, N. J., has been designated the 1951 winner of the Henry Laurence Gantt medal for "distinguished achievement in industrial management as a service to the community." Presentation of the award will be made November 28 at the Society's 72nd annual meeting at Atlantic City, N. J. Established in 1929, the Gantt medal is awarded jointly by the ASME and the American Management Association.

♦

The Weatherhead Co., Cleveland, recently announced that **B. R. Teree** has returned to the company as chief engineer of the aviation division. His former association with the company began in 1946 in the capacity of project engineer, and he was later advanced to director of laboratories and engineering manager. Most recently, Mr. Teree served as director of engineering for the hydraulic division of The New York Air Brake Co. at Watertown, N. Y.

♦

C. W. Miller has been named manager of large power transformer engineering for the Transformer division of the Westinghouse Electric Corp. at Sharon, Pa., succeeding the late W. G. James. Mr. Miller joined Westinghouse in 1928, later attended the Westinghouse Electric Design School and was transferred to the Transformer division engineering department in 1929. In 1948 he was appointed supervising engineer in the large power transformer section, and a year later was named section manager in charge of the shell form section.

♦

Igor Ivan Sikorsky has been awarded the Daniel Guggenheim Medal and certificate for 1951 "for a lifetime of outstanding contributions to aeronautics, including pioneering with multi-engine airplanes, flying boats, amphibians and helicopters." This medal was created for the purpose of honoring persons who make notable achievements in the advancement of aeronautics.

♦

In line with increased development-design requirements, Designers for Industry Inc., Cleveland, has appointed **Frank A. Grothe, William C. Albertson Jr., Herman Palter** and **Thomas Lock** to its staff. Mr. Grothe's new position is that of senior project designer of mechanisms related to electronic development; Mr. Albertson is also a senior project designer; and Messrs. Palter and Lock have been named project engineers.

♦

Assistant chief engineer since 1946, **Edwin Crankshaw** has been promoted to chief engineer for product and design for the Cleveland Graphite Bronze Co. He came to the company as a product design engineer in 1942 from the General Electric Co. at Lynn, Mass. Cleveland Graphite Bronze has also advanced **Joseph Palsulich,** staff engineer, and **Richard J. Schager,** assistant chief product engineer, to assistant chief engineers. Mr. Palsulich will specialize in aircraft bearings and allied products, and Mr. Schager, in automotive and diesel products.

♦

Gilbert I. Clark has been appointed project engineer of the American Cladmetals Co., Carnegie, Pa.

♦

Donald F. Warner has been appointed assistant to the manager of engineering for the General Electric Company's Turbine Department. In his new position he will co-ordinate and assist in the design and development of steam turbines, gas turbines and superchargers, and will be consultant to the Aircraft Gas Turbine Department. He will be located in the Lynn River, Mass., Works of the company.

♦

Associated with the company as chief development engineer since 1942, **Benjamin A. Main Jr.** has been elected vice president in charge of engineering for Aeroquip Corp., Jackson, Mich.

♦

To be in charge of engineering and research, **Gunnar Palmgren** was recently elected a vice president of SKF Industries Inc., Philadelphia. Associated with the company for 32 years, Mr. Palmgren was formerly assistant vice president and chief engineer.

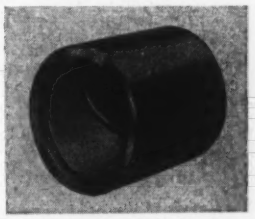
NEW PARTS AND MATERIALS

. . . presented in quick-reference data sheet form for the convenience of the reader. For additional information on these new developments, see Page 175

NYLON-LINED BEARING 1

. . . can be used without lubrication

Thomson Industries Inc., Manhasset, Long Island, N. Y.



Consisting of an outer metal sleeve with a nylon liner, these bearings can be used under adverse lubricating or temperature conditions.

Designation: Nylined.

Size: To specifications.

Service: Temperatures to 250 F; needs no lubrication on many applications; develops glazed surface with low friction coefficient; damps mechanical vibrations; compensation gap in liner allows for thermal expansion, permitting close shaft fits and preventing seizure; unaffected by ordinary chemicals; can be press-fitted or clamped.

Design: Plain sleeve or flange with separate nylon bearing surface for thrust load; nylon FM-10001 liner, with compensation gap, is retained in metal sleeve with two retaining rings; annular grooves for lubricant flow can be provided in metal sleeve, with lubrication through compensation gap.

For more data circle MD 1, Page 175

REGULATING VALVE 2

. . . for close control of power cylinders

Hydraulic Equipment Co., 1100 E. 222nd St., Cleveland 17, O.

In lowering heavy loads, outflow of scavenger oil from the double-acting cylinder is matched to inflow of oil on the power side to keep the cylinder from settling faster than the pump can supply oil.

Designation: 450 series.

Size: ½ or ¾-in. port size; approx. 6¼ in. long, 1¼ in. wide, 3⅛ in. high.

Service: Prevention of hydraulic voids in double-acting cylinder operation by regulating flow of scavenger oil; capacity 15 gpm at 1000 psi.

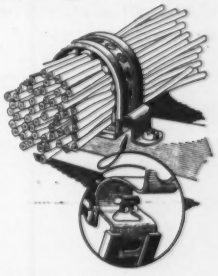
Design: Automatic plunger type: bidirectional—will control flow from either side of cylinder; drop in line pressure on power side causes spring to force plunger into position to restrict flow of scavenger oil.

For more data circle MD 2, Page 175

WIRE HARNESS CLAMP 3

. . . opens or closes without tools

Tinnerman Products Inc., Box 6688, Dept. 14, Cleveland 1, O.



Bundles of wires are held securely by spring pressure on a tongue and groove locking assembly.

Designation: Part No. A30114.

Size: Wire bundle diam (in.) as follows, ⅛, ⅛ to ¼, $\frac{5}{16}$ to ⅜, ⅜ to $\frac{7}{16}$, ½ to ⅝, $\frac{11}{16}$ to ¾, ¾ to ⅞, ⅞ to 1, 1 to 1$\frac{1}{16}$, 1⅛ to 1$\frac{3}{16}$, 1¼ to 1$\frac{5}{16}$.

Service: Spring pressure holds clamp closed—can be opened by hand pressure; variations in bundle diam can be accommodated; can be preassembled to bundle before mounting; meets max loading requirements for military aircraft.

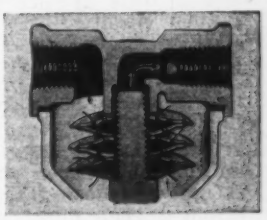
Design: T-shaped tongue on clamp slips into slot on base; spring pressure retains tongue in groove; extruded synthetic cushion, $\frac{1}{32}$-in. thick.

For more data circle MD 3, Page 175

GASOLINE FILTER 4

. . . compact and light-weight

Sparkler Mfg. Co., Mundelein, Ill.



Light enough to be supported by the fuel line only, this filter employs a nonwoven cloth filter.

Designation: Rayclean model MB.

Sizes: 2 in. OD, 2¼ in. high; weight, 3¼ oz.

Service: Filtration of microscopic particles, dirt and rust from gasoline; filter-cloth fibers cannot come loose; trap chamber holds water extracted from gasoline; filtering path sealed to prevent gasoline from bypassing filter element.

Design: Nonwoven rayon cloth, covering each filter disk, removes particles; cast-aluminum top; aluminum alloy bowl; all parts rust-resistant; replacement disks available.

For more data circle MD 4, Page 175

NEW PARTS AND MATERIALS

RELIEF VALVE 5

. . . controls low air pressures

Andrews-Alderfer Processing Co. Inc., 127-3 Ash St., Akron 8, O.

This pancake type relief valve can be attached to either flexible or rigid surfaces.

Designation: Andal A-120.

Size: 7⅜ in. OD; 1⅛ in. high.

Service: Air-pressure relief in 2-3 psi range; withstands government salt-spray tests, aging and dirt-accumulation tests; can be mounted on flexible surfaces with adhesives, rigid surfaces by bolting (holes drilled to specifications).

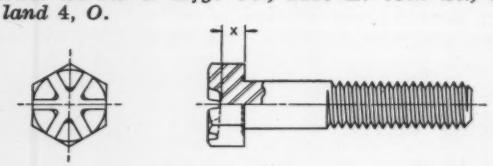
Design: Pancake type; flexible rubber base and shield, either natural or solvent-resistant neoprene; stainless steel cap, spring and components.

For more data circle MD 5, Page 175

SELF-LOCKING BOLT 6

. . . holds by spring action of bolt head

National Screw & Mfg. Co., 2440 E. 75th St., Cleveland 4, O.



When drawn up against a rigid seat, these cold-forged bolts require no nuts or washers to lock against vibration.

Designation: Slotted Place Bolt.

Size: American Standard sizes, ¼ to 1 in., coarse or fine thread pitches.

Service: Diaphragm-spring action of head maintains initial bolt tension and secures against vibration, fatigue or shock failures; shear section of head is stronger than mean equivalent area of thread, giving bolt a load-carrying capacity equal to that of conventional bolt or cap screw; reusable.

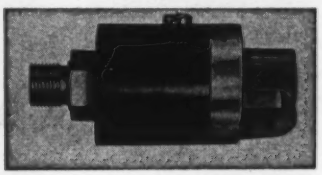
Design: Upset-forged head has six slots in top and circular recess underneath; as bolt is tightened against a rigid seat, pressure on bearing area outside of recess slightly displaces the segments to effect spring action; available in carbon or alloy steel; grain flow continuous through shank and head.

For more data circle MD 6, Page 175

ROTATING AIR UNION 7

. . . has replaceable carbon seal face

Deublin Co., 1155 Waukegan Rd., Glenview, Ill.



Balanced air pressure within the unit maintains constant sealing force regardless of pressure.

Designation: Model 1105.

Size: 1¾ in. diam, $4\frac{7}{16}$ in. long; for ⅝-18 NF or ⅜-in. pipe thread except "in-the-shaft" model for ⅜-in. pipe thread only.

Service: Sealing rotating connections at 150 psi pressure, 3500 rpm; low operating-temperature rise; carbon seal face replaceable; low starting and running torque; requires flexible hose connection to air line.

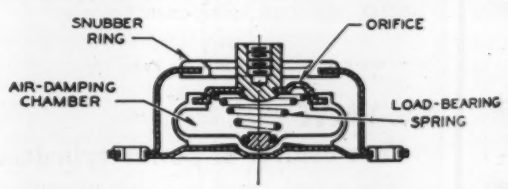
Design: Seal is hardened and lapped tool steel running against lapped carbon face; two sealed-for-life ball bearings for rigidity; aluminum housing and end-bell; available in standard model for overhang mounting (shown) or "in-the-shaft" model for mounting inside of bored hole in end of shaft.

For more data circle MD 7, Page 175

VIBRATION ISOLATOR 8

. . . air-damped to reduce resonance

Barry Corp., 822 Pleasant St., Watertown 72, Mass.



A new mount, covering an intermediate load rating, is available in the 780 and 896 type mountings of this manufacturer.

Designation: 780, 780R, 896, 896R

Size: 2⅜ x 2⅜ in. square base; 780 has $1\frac{7}{8} \pm \frac{3}{64}$-in. loaded height; 896 has $1\frac{13}{32} \pm \frac{3}{64}$-in. loaded height.

Service: For mounting units subject to shock and vibration; load rating 8 to 16 lb; air-damping reduces resonance effects, eliminating contact with snubber at resonance; vertical resonance, 7 to 9 cycles per sec; max. amplification at resonance, 3.5; rapid decay of shock-excited oscillations; nonlinear springs give substantially constant resonant frequency; low drift or permanent set; 780R and 896R are "ruggedized" to meet requirements of spec. AN-E-19 for equipment sizes listed in JAN-C-172C.

Design: Stainless-steel spring supports load; rubber air-damping chamber with orifice; rubber snubber ring; silicone rubber can be supplied for extremely high or low temperatures.

Application: Instruments, fans, airborne electronic equipment.

For more data circle MD 8, Page 175

Standard Tests for Sleeve Bearings-2

AS pointed out in the preceding data sheet—"Standard Tests-1"—the prime reason for the large number of tests employed is simply to assure the user that he is getting the greatest bearing performance possible for his money. This is necessary in Sleeve Bearings not only because there are so many types of bearings available but also because it is possible to so design any type to secure all the necessary properties. Cast bronze is a good example. There are approximately one hundred separate and distinct alloys from which to choose. If plasticity and/or embeddability is a chief requirement the usual method is to increase the lead content. If greater hardness is required, the lead content is lowered, then tin, or nickel, or manganese, for instance, is increased.

One of the chief points to remember in specifying sleeve bearings is that they can be "tailor-made" to suit practically any application. The only requirement is that we first determine all of the pertinent operating factors.

Johnson Bronze Alloy No.	PHYSICAL PROPERTIES			
	(1) Wear Rate (dry)	(2) Coefficient of Friction (dry)	(3) Izod Notch Toughness	(4) Resistance to Pounding
19	0.24	0.16	3.4	54
25	0.36	0.14	5.2	22
27	0.32	0.19	4.4	63
29	0.35	0.16	5.6	40
51	0.63	0.25	8.3	81
53	0.62	0.26	8.5	86
55	0.53	0.29	3.9	109
66	0.50	0.19	8.4	20
71	0.64	0.18	12.1	20
72	0.41	0.19	8.6	38

A typical listing and comparison of various popular, cast bronze bearing alloys.

Resistance to Fatigue

This is the ability of the bearing material to withstand shocks and loads without deterioration or fracture. It is particularly valuable in testing bearings for internal combustion engines with rapidly alternating stresses on bimetal bearings such as steel backed, babbitt or bronze lined.

Izod Notch Toughness

This determines the amount of energy in foot pounds required to break a specimen. The specimen is notched and the energy required to fracture in a single blow indicates the toughness.

Resistance to Wear

This test determines the physical ability to resist destruction of two surfaces rubbing together without lubrication. The results are usually tabulated in the loss of weight in grams per 10,000 revolutions.

Resistance to Pounding

This is determined by establishing the number of blows of a hammer weighing 7.5 pounds, falling 2 inches, are required to deform the specimen 5%.

Coefficient of Friction

This test in bearing material is always computed on a "dry" basis, or a set up in which no lubricant of any kind is used. It is usually determined on an Amsler wear test machine.

Thermal-Conductivity

Thermal-conductivity is the ability of a bearing or bearing material to dissipate heat. It is a determination of the B.T.U.'s, per unit of time that will move through the material.

•

Engineering Service

Johnson Bronze offers manufacturers of all types of equipment a complete engineering and metallurgical service. We can help you determine the exact type of bearing that will give you the greatest amount of service for the longest period of time. We can show you how to design your bearings so that they can be produced in the most economical manner. As we manufacture all types of Sleeve Bearings, we base all of our recommendations on facts free from prejudice. Why not take full advantage of this free service?

•

This bearing sheet data is but one of a series. You can get the complete set by writing to—

Johnson Bronze

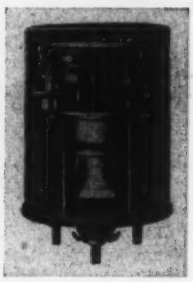
SLEEVE BEARING HEADQUARTERS
525 S. MILL ST. • NEW CASTLE, PENNA.

NEW PARTS AND MATERIALS

TIME-DELAY RELAY 9

. . . available in six time ranges

R. W. Cramer Co. Inc., Centerbrook, Conn.



Hermetically sealed, this miniature time-delay relay meets U. S. military requirements.

Designation: HTI.

Size: A-c, d-c, $3\frac{55}{64}$ in. high, $2\frac{9}{16}$ in. diam; 400-cycle, $4\frac{3}{4}$ in. high, $2\frac{9}{16}$ in. diam.

Service: Overload protection or time-limit control; fixed time delay between closing of control circuit and closing or opening of secondary circuit of 30, 60 sec, 2, 5, 15 or 30 min; for 110 v 50/60 cycles, 110 v 400 cycles, 6 or 27 v d-c; latter available in 2 styles—nongoverned with ±10% accuracy or with chronometric governor with 0.5% accuracy; 220 v 50/60 or 400-cycle extra; switch rating, 5 amp at 115/250 v, 50 through 400 cycles noninductive or 2 amp at 28 v d-c at sea level, 1½ at 50,000 ft; resets on power failure; setting accuracy, ±3% of overall time range; repeat accuracy, ±1%; temperature, −65 to +160 F; acceleration, 15 *g* nonoperating; vibration, 5 to 60 cycles per sec at $\frac{1}{32}$-in. amplitude; salt spray, 200 hr; inclination ±90 deg; humidity, 100% plus condensation; fungus, dust and sand-proof.

Design: Switch, single-pole double-throw, second pole available; self-starting synchronous a-c or permanent-magnet d-c motor drives switch operating mechanism through differential clutch system; drawn shell, hermetically sealed; solder type terminals.

For more data circle MD 9, Page 175

PRECISION SWITCH 11

. . . for direct-current applications

Micro Switch Div., Freeport, Ill.

A magnetic blowout is incorporated in these small-size switches, which may be used with relatively high currents.

Designation: MT-4R, -4RL, -4RL2.

Size: Body $1\frac{13}{16}$ in. long, $\frac{11}{16}$-in. wide, $\frac{37}{32}$-in. high; weight, 1 oz.

Service: D-c switching with ratings as follows;

D-c Voltage (v)	Motor Load (hp)	Inductive Load (amp at 0.14 h)	Resistive Load (amp)
	Nonpolarized		
115	¼	3	10
	Polarized		
115	½	5	10
230	½	3	5

Characteristics as follows;

	MT-4R	MT-4RL	MT-4RL3
Operating force	10-15 oz	5½ oz, max	5½ oz, max
Release force	5 oz, min	½-oz, min	½-oz, min
Pretravel	0.035-in., max		
Free position		$\frac{11}{32}$-in., max	$1\frac{13}{32}$ in., max
Overtravel	0.005-in., min	0.062 in., max	0.062 in., max
Movement	0.005-in., max		
Operating point		0.719-0.781-in.	1.156-1.219 in.

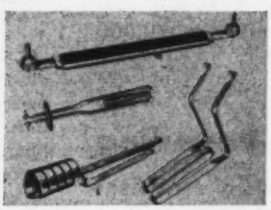
Design: Single-pole, double-throw; MT-4R has pin plunger actuator; MT-4RL has leaf actuator; MT-4RL2 has roller-leaf actuator; magnetic blowout; plastic case.

For more data circle MD 11, Page 175

HEATING ELEMENTS 10

. . . can be formed into intricate shapes

Syntron Co., 260 Lexington Ave., Homer City, Pa.



These thin, flat electric elements are available in several sheath materials.

Size: 9 to 124 in. long, $\frac{17}{32}$ or $\frac{33}{32}$-in. wide, $\frac{1}{16}$-in. thick.

Service: Heating by contact, direct or indirect immersion; maximum allowable watts per square in. heated surface varies from 5 to 65, depending on operating and ambient temperature and sheath material; max operating temperature, 1200 F in free air; can be supplied as self-regulating, with wattage varying inversely with heater temperature; heater can be bent sidewise, edgewise or twisted.

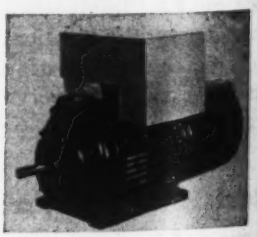
Design: Heating element is sinuated into flat helix; metallic-oxide insulation resists fluxing if arcing occurs, preventing grounding of resistor to sheath; strap, stud or ribbon terminals, insulated with mica and compacted silica from copper or steel sheath (alloy, chrome steel, scale-resistant or others available); single or double bushings, pressure flanges or pipe plug and cover available for brazing to sheath.

For more data circle MD 10, Page 175

REMOTE CONTROL 12

. . . for variable-speed transmission

Graham Transmissions Inc., 3754 N. Holton St., Milwaukee 12, Wis.



Easily installed in the field, this electric remote control can be added to any standard Graham variable-speed transmission.

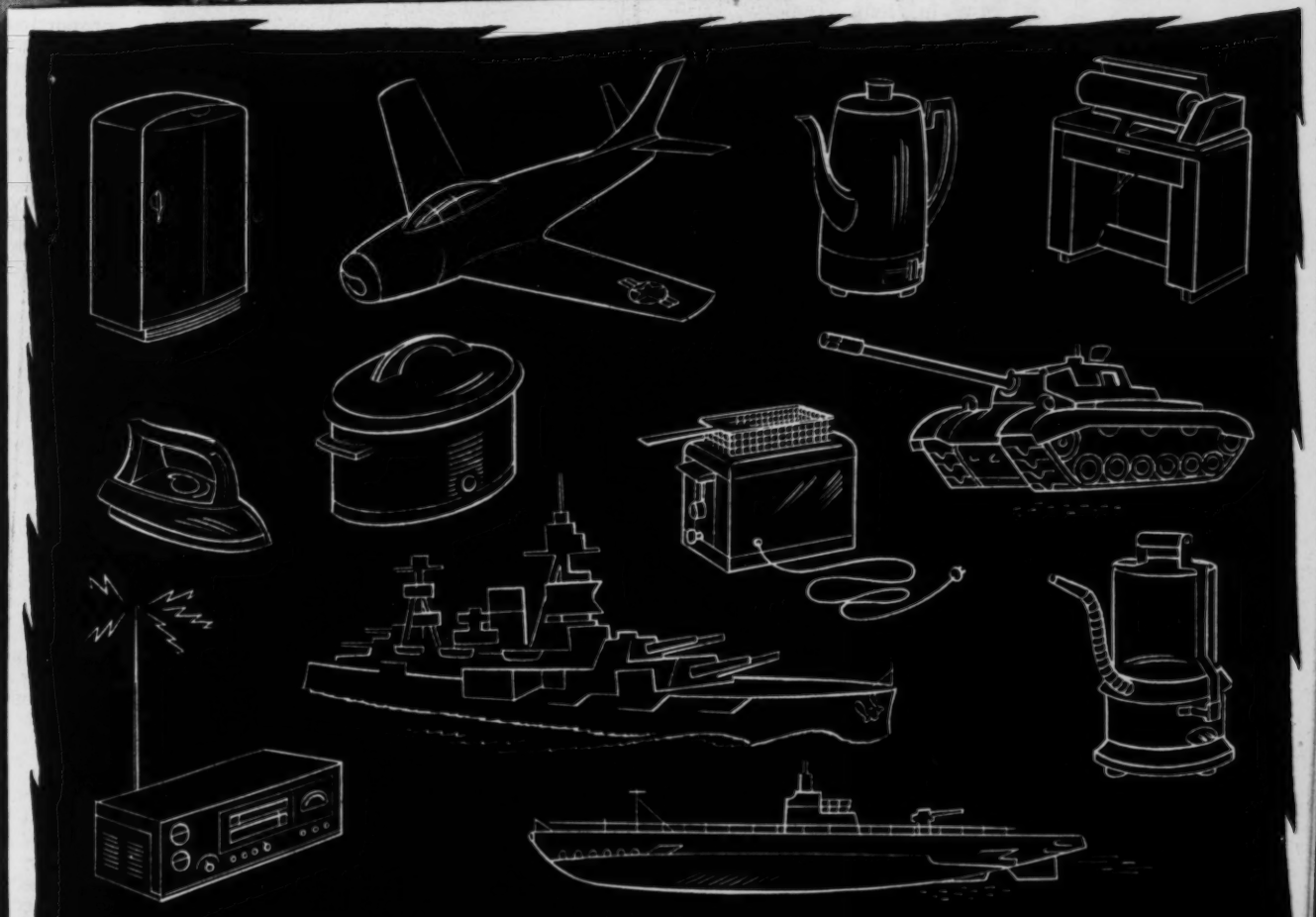
Size: Approximately 6¼ in. long x 11¼ in. wide x 6 in. high.

Service: Remote speed-setting of ¼ to 5 hp Graham variable speed transmissions over complete range from maximum to zero; can be mounted in field; operates on 115 v a-c current; control motor may be operated continuously in locked-rotor condition; reversible motor supplies 6 lb-in. torque to mechanical control mechanism of transmission at speed of 4.5 rpm.

Design: Pushbutton remote operation; 25 v, 60 cycle a-c reversible motor draws power from 35 va capacity transformer and supplies power at 360:1 gear reduction to mechanical control mechanism of transmission; available with or without remote indicator, which consists of a potentiometer fixed to the mechanical control mechanism and connected to a rectifier type voltmeter; indicator calibrated in units desired.

For more data circle MD 12, Page 175

the *special* thermostat you need may be a Stevens *standard*...



Whatever your *special* thermostatic control needs—whether for appliances, apparatus, communications and avionic equipment, or for government work—check with Stevens *first*. For Stevens makes the widest range of bimetal thermostats in the industry. And chances are a *standard* Stevens thermostat will satisfy all your *special* requirements for performance, size, cost and delivery.

STEVENS

manufacturing company, inc.

FIELD, OHIO

NEW PARTS AND MATERIALS

PILOT LIGHT 13

. . . with long-life neon lamp

Industrial Devices Inc., Edgewater, N. J.

Operating on a-c or d-c, this lamp provides a soft light with no heat.

Designation: Omni-Glow model 1010.

Size: 5/8-in. OD, 1¾ in. long; requires ½-in. diam mounting hole.

Service: For vibration, shock and heavy duty; withstand overload; operates on 75 to 250 v, a-c or d-c; resistors available for different voltages or light intensities; Fresnel lens provides even light distribution; red color is standard, translucent, clear, amber or other, special; lamp rated 10,000 hr of operation; tested by UL.

Design: Nylon plastic tube contains lamp and built-in resistor; styrene lens; 4½ in. leads insulated with 80 deg C, 600 v plastic insulation; leads stripped bare and tinned for last ½-in.; spring retaining nut fastens to nylon body; polished metal collar connects lens and body; ring-tongue terminals or special leads available.

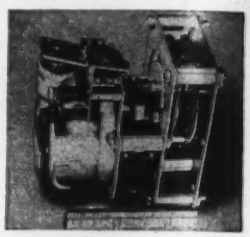
For more data circle MD 13, Page 175

DELAYED-RESET RELAY 15

. . . protects power circuits

A. W. Haydon Co., 232 N. Elm St., Waterbury, Conn.

Time delay in reclosing circuit is proportional to duration of current interruption.



Size: 3¾ in. long, 2 7/32 in. wide, 3 5/32 in. high; weight approx. 20 oz.

Service: Delayed reset-time delay proportional in length to current interruption time, with maximum delay of 7 min; other ranges can be incorporated; available for 24 v d-c or 115 v 60 cycle current; temperature, −55 to 100 C; vibration, 5 to 55 cycles per sec with specials to 500 cycles per sec; acceleration, 10 *g*; with hermetic enclosure resists salt spray, humidity, dust and sand, oil spray.

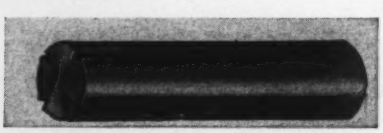
Design: Single-pole switch mechanism driven by a-c or d-c motor; dust cover or hermetically sealed enclosure; radio-interference filtering, governed d-c motor or additional switches available.

For more data circle MD 15, Page 175

DOWEL PINS 14

. . . stay in place under heavy vibration

Driv-Lok Pin Co., Sycamore, Ill.



Four parallel grooves lock this pin to one part of assembly while mating part can easily be separated from ungrooved portion of pin.

Designation: Lok Dowel.

Size: Nominal diam (in.) ⅛, 5/32, ¼, 5/16, ⅜, ½; length (in.), ⅜ to 1 in. ⅛-in. steps, 1 to 2 in ¼-in. steps; specials available.

Service: Doweling, locating, hinging parts; when dowel pin is forced into hole, crests of 8 flutes are substantially forced back into grooves, causing outward radial forces to lock grooved portion of pin into place; ungrooved portion can be freed from hole in mating part without seizing; length tolerance, ±0.010-in.; nominal diam tolerance, −0.0005, +0.0000-in.

Design: Cold-drawn B-1112 steel pin, centerless ground and polished, has 4 grooves impressed along half of length, forming upset flutes on each side of groove; drill-rod or stainless-steel pins available.

For more data circle MD 14, Page 175

PLASTIC TUBING 16

. . . for severe service conditions

Resistoflex Corp., Belleville 9, N. J.

High dielectric values and resistance to acids, alkalies, gasoline and tropical exposure make this tubing suitable for electric wiring or other service under extreme conditions.

Designation: Fluoroflex-C.

Form: Extruded tubing.

Size: To specifications up to ½-in. ID; wall thickness 0.010-in. min to 0.100-in. max.

Service: Insulating, wiring and harnesses; temperatures from −150 to +375 F unplasticized, −70 to +250 F plasticized; plasticized variety recommended where extreme flexibility required; nonflammable; unaffected by concentrated acids and alkalies, gasoline, oil, high humidity.

Properties: Color, colorless to cloudy, depending on wall thickness; specific gravity, 2.0-2.2; tensile strength (at 77 F), 5500 psi; flexural strength (77 F), 8000 psi; dielectric constant (60 cycles per sec, −50 to +180 C) 2.5-3.1, (10^8 cycles per sec, 25 C) 2.5; dielectric strength (short time, ⅛-in.) 2500 v per mil, (step by step, 0.005-in.) 5000 v per mil; arc resistance, greater than 360 sec; volume resistivity (at 25 C), 1.2×10^{18} ohm-cm.

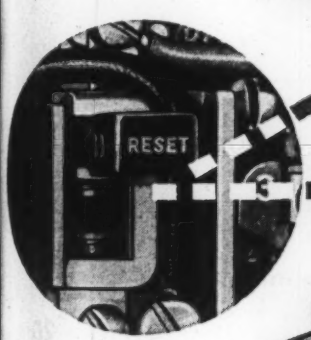
For more data circle MD 16, Page 175

NEW!

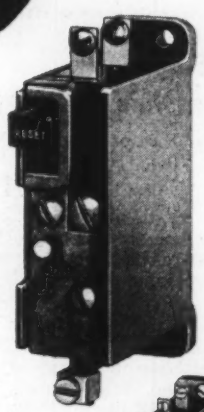
R-B-M

A. C. MAGNETIC STARTERS

Line Voltage Type



With *Visible Contact* Overload Relays



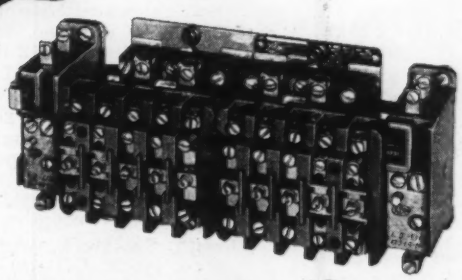
- Heater element cannot be assembled to starter incorrectly.
- Bi-metallic thermal overload relay assembly replaceable without removing starter from enclosure. Designed for separate mounting without subpanel assembly.
- TRIP-FREE Manual reset is standard. Manual-Automatic Reset available on special order at no extra cost.

R-B-M Size 0 and 1 A.C. Magnetic Starters have identical overall panel mounting dimensions. All parts, except stationary and movable contact assemblies, are common to both sizes.

Ilsco solderless lugs, suitable for #6 maximum wire size, are standard. Screw terminals are available on special order. Magnet coil can be removed without disassembling starter. Stationary and movable contacts replaceable without disconnecting wiring. Enclosed heater element, expanding U-shaped bi-metal and snap action contact mechanism provide dependable, accurate motor overload protection.

Small overall size, plus identical mounting dimensions for 10 and 15 ampere 2 to 5 pole contactors, as well as Size 0 and 1 non-reversing starters, make the R-B-M line extremely flexible for control panel layout.

Address Department B-11



Two 5 pole contactors mechanically interlocked with overload protection on common base. Unwired. Note interchangeability of 25 ampere normally open contacts and 15 ampere convertible N.O. or N.C. interlocks.

R-B-M DIVISION ESSEX WIRE CORP.

Logansport, Indiana

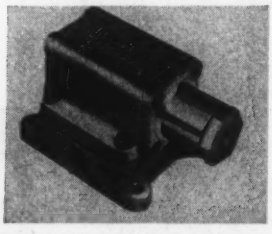
MANUAL AND MAGNETIC ELECTRIC CONTROLS — FOR AUTOMOTIVE, INDUSTRIAL, COMMUNICATION AND ELECTRONIC USE

NEW PARTS AND MATERIALS

AIR VALVES 17

. . . offer variety of operating methods

Mechanical Air Controls Sales Co., 15311 *W.* 11 *Mile Rd., Royal Oak, Mich.*



Control mechanisms are interchangeable, allowing wide choice of type of control. Basic body assembly is standard.

Size: ⅜-in. pipe size, 3⅜ in. long, 3 in. wide, 3 in. high; ¾-in. pipe size, 4⅞ in. long, 3⅝ in. wide, 3 2/3 in. high.

Service: For 150 psi air; control by cam, pilot pressure, foot, solenoid or hand; meet JIC specifications.

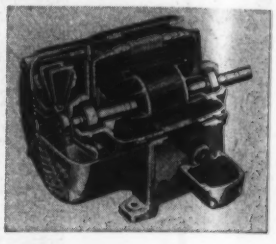
Design: Straightway, 3-way or 4-way; control mechanisms interchangeable by changing retainer or endplate; control action is direct on aluminum spool, which is only moving part; bronze body and retainer caps; lapped and hard-chrome plated bore; O-ring seals; cast-iron sub-base; available for double-cam or double-pilot control, or single control with spring return.

For more data circle MD 17, Page 175

EXPLOSIONPROOF MOTORS 19

. . . have asbestos-protected windings

U. S. Electrical Motors Inc., 200 *E. Slauson Ave., Los Angeles* 54, *Calif.*



Sealed housings and terminals offer protection against inflammable or dust-filled atmospheres.

Designation: SE, SES.

Size: SE, 3 to 75 hp; SES, ¼ to 2 hp.

Service: UL approved for Class I, Group D (inflammable gases and volatile liquids) and Class II, Groups F and G (combustible dust); bearings can be flush-lubricated since drain is included.

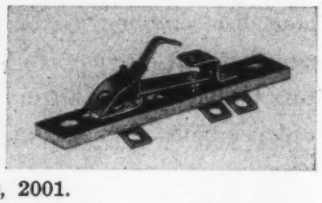
Design: Totally enclosed; windings are asbestos-impregnated and insulated with asbestos; split-hub fan on SE; sealed terminals; removable cover plate; normalized castings; centrifugally cast aluminum rotor.

For more data circle MD 19, Page 175

SNAP-ACTION SWITCHES 18

. . . have simplified coil-spring construction

Cherry-Channer Corp., 1488 *Skokie Blvd., Highland Park, Ill.*



Designed for appliances and automatic machinery, these open-mounted switches are stripped down and simplified.

Designation: Models 2000, 2001.

Size: Model 2000, 2⅛ in. long, $\frac{7}{16}$-in. wide, $\frac{15}{32}$-in. high; 2001, same except $\frac{13}{32}$-in. high.

Service: UL rating 6 amp at 125 v a-c, 3 amp at 250 v a-c; life expectancy (tested) 2.5 million operations at 1 amp to 1.5 million operations at 6 amp;

Model	Force (oz.) Operating	Force (oz.) Release	Pretravel* (in.)	Overtravel* (in.)
2000	7.5	5.5	⅛	$\frac{3}{32}$
2001	4.0	2.7	$\frac{3}{16}$	$\frac{3}{32}$

* ±0.025-in. standard, ±0.012-in. special.

Design: Single-pole, normally-open or closed, or double-throw; DPDT special; over-center coil-spring construction; cam-following actuator; ratchet, plunger or others special; spring, cadmium-plated piano wire; brass bracket and actuator; fine silver contacts; phosphor-bronze blade; Bakelite mounting panel.

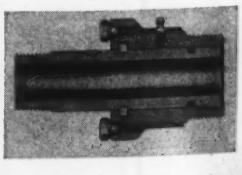
Application: Appliances, vending machines, bottling and packaging machines; sump pumps.

For more data circle MD 18, Page 175

SWING JOINT 20

. . . for gasoline and oil handling

Barco Mfg. Co., Dept. J-18, 1801 *Winnemac Ave., Chicago* 40, *Ill.*



Sixty models are available for both threaded and flanged connections.

Designation and Size: Style 5001, ⅜, ½, ¾-in. pipe, male threaded connections; style 5011, 1, 1¼, 1½, 2, 2½, 3 in. pipe, male threaded connections; style 5020, 4, 6, 8, 10, 12 in. pipe, flange connection, available with optional companion flange, internally threaded.

Service: Rotation of 360 deg; sealing pressures to 100 psi, 500 psi on smaller models; temperatures, −40 to +225 F; can handle air, gas, water, gasoline, fuel oil or other liquids without softening or swelling of seal; long bearing surface provides side-to-side rigidity.

Design: Sealing accomplished with O-ring; bearing surface lubricated through Alemite fitting on 5011, 5020; 5001 has steel casing and sleeve with metal washer and snap-ring retainer; 5011 (shown) has steel sleeve, malleable iron casing with thrust ring and flange retainer; 5020 has steel sleeve with semi-steel casing and flanges.

For more data circle MD 20, Page 175

wherever
PRODUCTS CAN BE
bettered
BY THEIR BEARINGS

All bearings are designed to eliminate costly friction . . . but only SEALMASTERS can offer the many *extra advantages* that SEALMASTERS' exclusive combination of features gives to your product.

SEALMASTER users report smoother machine operation—with reduced power consumption and minimum maintenance. The proved, all-around efficiency of SEALMASTER Ball Bearing Units is the best assurance of long life and dependable service under even the most difficult conditions.

Write for a copy of Catalog 845 . . . it tells the complete SEALMASTER story.

SEALMASTER
BALL BEARING
UNITS

1. PERMANENTLY SEALED
Felt-lined steel flinger, rotating in labyrinth, excludes dirt and retains proper amount of lubricant.

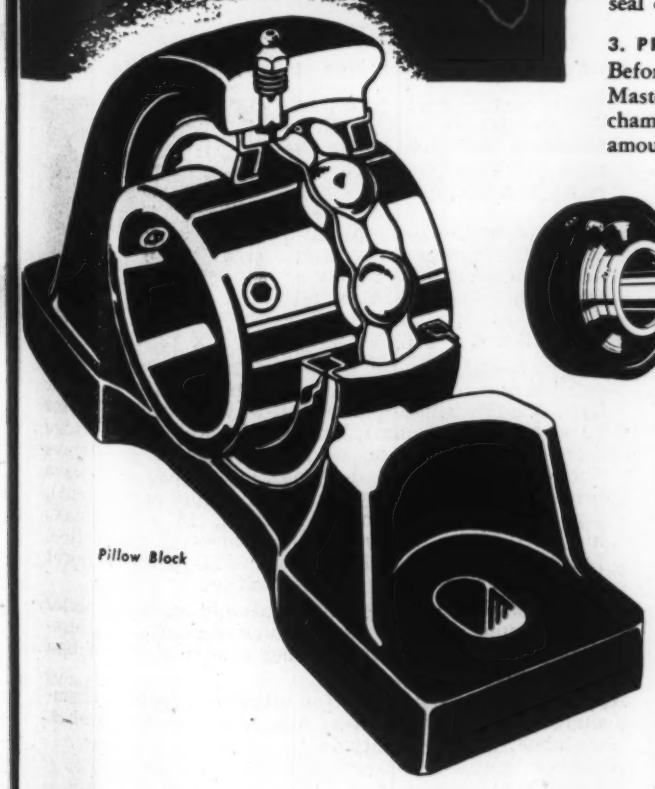
2. SELF-ALIGNING
Bearing unit, with seals independent of housing, can align itself in any direction without seal distortion.

3. PRE-LUBRICATED
Before shipment from the SealMaster factory, the bearing chamber is filled with proper amount of lubricant.

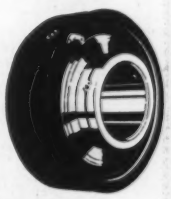
4. NO HOUSING WEAR
Patented locking pin and dimple prevent rotation of outer race in housing. This eliminates housing wear, permits shaft alignment and positions unit for relubrication.

5. FLOATING RETAINER
Ball retainer is designed to float on ground inner surface of outer race. Traps lubricant, prevents churning.

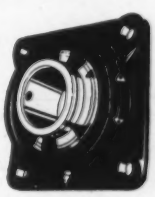
6. HOUSING DESIGN
SealMaster's cast housings combine rigid, one-piece construction with smooth streamlined appearance.



Pillow Block

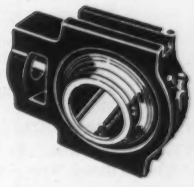


Cartridge unit



Flange unit

Flange-cartridge unit



Take-up unit

SEALMASTER BEARINGS
18 RIDGEWAY AVENUE, AURORA, ILLINOIS
A DIVISION OF STEPHENS-ADAMSON MFG. COMPANY

FACTORY REPRESENTATIVES AND DEALERS IN ALL PRINCIPAL CITIES

NEW PARTS AND MATERIALS

SOLENOID VALVE 21

. . . has low current consumption

A. F. Hoppe Engineering Inc., Greensboro, Ind.

Light weight is a feature of these 3-way valves. Typical is the ¾-in. model, which weighs 6 lb.

Size: ½ to 3 in. pipe size.

Service: High-pressure duty; valve operated by momentary-contact control; solenoids for 24, 110, 220 or 440 v 60 cycle a-c, or 6, 12, 18, 115 or 230 v d-c; solenoids withstand 500 F continuous duty; handle steam, air, oil, refrigerants, corrosive liquids.

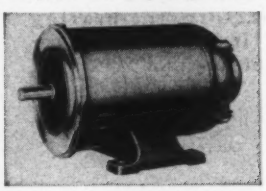
Design: Three-way; fabricated from bar stock in various stainless-steel alloys or brass.

For more data circle MD 21, Page 175

FACE-MOUNTED MOTORS 22

. . . for horizontal or vertical mounting

Hoover Co., Kingston-Conley Div., N. Plainfield, N. J.



Suitable for continuous-duty operation, these integral-hp motors have internally mounted condensers.

Size and Service: Single-phase, 115/230 v operation except 3 hp, 230 v only; polyphase motors are dual voltage, 208-220/440 v, with dual frequency on some; dripproof; NEMA type C;

Single Phase			Polyphase		
Size (hp)	Speed (rpm)	Cycles	Size (hp)	Speed (rpm)	Cycles
¾	1140	60	¾	1140	60
1	1725	60	1	1725/1425	60/50
	1425	50		1140	60
	1140	60	1½	3450/2850	60/50
1½	3450	60		1725/1425	60/50
	2850	50		1140	60
	1725	60	2	3450/2850	60/50
	1425	50		1725	60
2	3450	60	3	3450	60
	1725	60		1725	60
3	3450	60	5	3450	60

Design: Face-mounted; horizontal motors also include mounting base; verticals are equipped with canopy; single-phase are capacitor start or capacitor start and run; single-phase have dust and dirtproof external switch housings, condensers mounted within motor base; heavy duty ball bearings.

Application: Pumps, machine tools.

For more data circle MD 22, Page 175

GASKET MATERIAL 23

. . . resists gasoline and oil

Rogers Corp., Manchester, Conn.

Fabricated from asbestos and neoprene, this material has a low water-absorption rate and good bursting strength.

Designation: Duroid 3102.

Form: Fabricated; asbestos-neoprene.

Size: 0.031 to 0.125-in. thick.

Service: For gaskets at up to 300 F temperature; high flexibility; good gasoline, water and oil resistance.

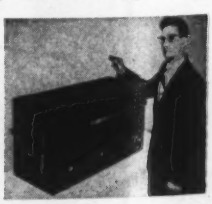
Properties: Density, 1.45 gm per cc; weight, 23.7 gm per cu in.; tensile strength (lengthwise) 4500 psi, (crosswise) 2000 psi; bursting strength, 500 psi; water absorption (24 hr), 15%; compressibility (1000 psi), 15%; recovery, 95%; loss in tensile strength (72 hr in boiling water) 40%, (50% methanol aqueous solution at 150 F) 38%.

For more data circle MD 23, Page 175

SELENIUM RECTIFIERS 24

. . . available in large sizes

Syntron Co., 260 Lexington Ave., Homer City, Pa.



When custom-made into power conversion units, these selenium cell units can be used for rectifying high currents and voltages.

Size: Cells, before assembly into stacks for power conversion, are available in following sizes (in.)—1 x 1, 1¼ x 1¼, 1½ x 1½, 1¾ x 1¾, 2 x 2, 2 x 3, 3 x 3, 3 x 4, 4 x 4, 4 x 6, 5 x 6, 6 x 6, 6 x 8, 6 x 10, 6 x 12, 12⅜ x 16.

Service: Rectifying a-c to d-c at 26 rms v max per cell; common circuits are single-phase half-wave (for light loads), single-phase full-wave center-tap (for 10 v d-c output max.), single-phase full-wave bridge (any d-c voltage or current), 3-phase half-wave (heavy loads, 10 v d-c max.), 3-phase full-wave bridge (high efficiency, small d-c ripple component), 3-phase center-tap (heavy current, 14 v d-c max., high efficiency, low ripple component); convection, fan or oil cooling; use of larger cells permits fewer parallel elements for given d-c voltage.

Design: Selenium deposited on aluminum base plates by vacuum process, giving thick deposit; pressure-spring contact washer provides electrical connection between cells.

Application: Power packs for vibrators, feeders; hammers; business machines; magnetic chucks; brakes, clutches; elevator controls.

For more data circle MD 24, Page 175

ENGINEERING DEPARTMENT

EQUIPMENT

For additional information on this new equipment, see Page 175

CONTACT PRINTER 25

. . . for photocopying large drawings

Remington Rand Inc., 315 *Fourth Ave., New York* 10, *N. Y.*

Vacuum sealing of original drawing against copy paper, plus a dimmer control on the lights, adds to flexibility and accuracy of reproduction.

Designation: Portagraph.

Size: Copy surface area, 30 in. x 42 in., 42 in. x 60 in.

Service: Photographic reproduction; light intensity can be varied, eliminating use of amber light for exposure control; instrument panel illuminated for use in darkroom working conditions.

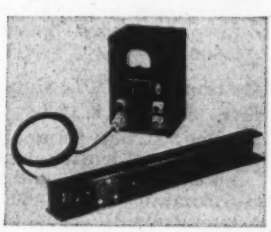
Design: Dimmer rheostat controls printing lights; vacuum sealing; timer; vacuum gage; finished in American Walnut.

For more data circle MD 25, Page 175

VELOCITY INDICATOR 26

. . . measures stroke of high-speed members

Aero Electronics Co., 1902 *W. Division St., Chicago* 22, *Ill.*



Instantaneous velocity, position, and velocity vs. position can be measured for mechanisms having long strokes.

Size: Control box, 7½ in. high, 6⅜ in. wide, 2½ in. deep; slide-wire, 2 to 48 in.

Service: Measuring instantaneous displacement and velocity of moving mechanisms; measures periodic or nonrecurring movements; oscillograph must be used for recording data; use of straight slide-wire resistance element gives continuous record; instantaneous velocities to 300 ft per sec; accuracy of slide-wire, ±0.1%, of typical circuit with commercial oscillograph, ±2%.

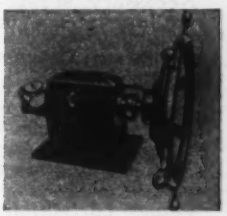
Design: Moving member is attached to sliding contact; voltage from slide-wire, proportional to displacement of sliding contact, is picked up by differentiating network and fed to oscillograph; voltage indicator, calibrating and voltage-adjusting circuit included; sliding contact comes free of slide-wire assembly for drop or destructive testing.

For more data circle MD 26, Page 175

SHEET-METAL TESTER 27

. . . determines "drawability" of metal

J. Arthur Deakin & Son, 130-28 *Hillside Ave., Jamaica* 2, *N. Y.*



Developed for making Erichsen tests on metals, this tester can help in establishing quality specifications and material controls.

Designation: Alexander.

Size: For test samples 3½ in. square, up to $\frac{5}{64}$-in. thick; interchangeable tools for narrow strips of $\frac{3}{64}$, ¾ or 1 in. width, or coin blanks, can be supplied.

Service: Determining fracture point of sheet metal; depth of impression can be read to 0.0004-in.; pressure gage supplied for 0-30 cwt, 0-6 tons or 0-20 tons pressure.

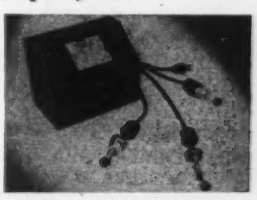
Design: Test piece clamped between dies so metal can "flow"; round-end tool is forced into metal by hand wheel until fracture occurs; depth of fracture point, observed by operator in mirror, is read from micrometer scale; gage, set to zero at start of draw, indicates pressure exerted; main finger of gage carries "jockey" finger which shows maximum deflection.

For more data circle MD 27, Page 175

VACUUM GAGE 28

. . . for high-vacuum systems

Hastings Instrument Co. Inc., Hampton, Va.



Fast response, accuracy of calibration with any length cable and interchangeability of pickups are features of this gage.

Size: Indicator instrument, 7 in. long, 4½ in. wide, 4¼ in. high; gage tube, $1\frac{9}{32}$ in. OD, 2¾ in. length, ½-cu in. internal volume, 2 oz weight; ⅛-in. IPS male thread.

Service: Measuring vacuum in range 1 to 1000 mu Hg; response less than ½-sec; voltage, 110-120 v, 50-60 cycle a-c, can be used from 90-135 v, 30-800 cycle a-c; current, 0.01-amp; power, 1 w; pickups can be interchanged without recalibration; free from outgassing and corrosion; calibration not affected by connecting-cable length.

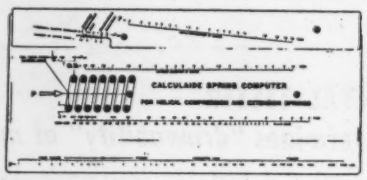
Design: Hot junctions of noble-metal thermopile are heated by alternating current; d-c current generated across hot and cold junctions depends upon thermal conductivity of gas, and increases as vacuum increases; half-bridge circuit separates a-c power and d-c measurement currents.

For more data circle MD 28, Page 175

SPRING COMPUTER 29

. . . correlates all data in one setting

American Hydromath Co., 145 *W. 57th St., New York, N. Y.*



Necessary spring-design data is read off directly, without intermediate computations.

Designation: Calculaide.

Size: 11⅜ in. long, 5 in. wide.

Service: Solving helical compression and extension spring problems; correlates OD of spring, wire diam in inches and gage number, number of active coils, material and its torsional modulus, maximum shear stress, load, and total deflection; stress scale includes correction for nonlinear distribution of torsional stress in curved wires; gives correct results for large deflections of extension springs where calculated values are usually too high; washable; nonwarping and dimensionally stable.

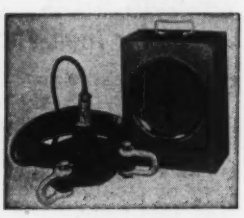
Design: Vinylite plastic sheet; scales printed in contrasting colors, laminated into body of plastic.

For more data circle MD 29, Page 175

LOAD INDICATOR 30

. . . measures tension, weight, tractive loads

W. C. Dillon & Co. Inc., 1421 *S. Circle Ave., Forest Park, Ill.*



Remote indication up to 400 ft away is provided by the oversize selsyn-motor system.

Designation: Tens-O-Trol.

Size: Cabinet, 9 in. wide, 11¾ in. tall, 5 in. deep, weight 12 lb; dial, 6⅜ in. diam; transmitter weight, 9 lb; cable in length specified.

Service: Remote indication of tension, weight or tractive loads; 12 capacity ranges from 0-500 to 0-50,000 lb; accuracy, ±2% full-scale reading; current, 12 v d-c from dry battery.

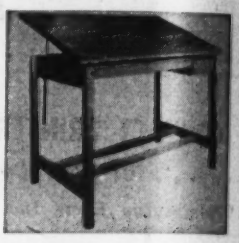
Design: Movement of calibrated beam on traction dynamometer is transferred to ball-bearing selsyn motor; motor is connected by 5-conductor rubber-covered cable, with aircraft type interlocking sockets, to repeater selsyn motor in indicator cabinet; on-off switch on cabinet; one or two indicators may be used at distances required; steel cabinet; baked gray-enamel finish on cabinet and dynamometer; clear plastic crystal; dial is gray with black figures; red pointer, counterbalanced.

For more data circle MD 30, Page 175

DRAWING TABLE 31

. . . has maple frame, basswood top

Kingsley Mfg. Co., 748 *E. 82nd St., Cleveland* 3, *O.*



A replacement warranty on the basswood top, guaranteeing it against warping, is offered by the manufacturer.

Size: Drawing surface, 36 x 60 in., 36 x 72 in. standard, others special; top, 1⅛ in. thick; working height, 37 in.; tracing drawer, 36 x 26 x 2 in.; tool drawer, 11 x 18 x 4 in.

Service: Hinged top adjustable to 0 to 55 deg angle; round hard-maple apron protects large drawings; end and underside cleats reinforce top to preclude warping and allow for expansion and contraction of drawing surface while holding a true drawing edge.

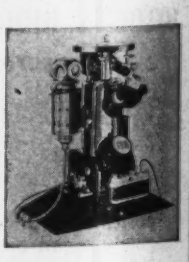
Design: Basswood top; hard-maple frame, assembled with Woodloc metal fasteners; joints are dowel-pin reinforced; hard-maple end cleats and underside cleats on drawing board; double foot-rest; tool drawer has lock and key.

For more data circle MD 31, Page 175

OPTICAL INSTRUMENT 32

. . . for examining, photographing materials

F. T. Griswold Mfg. Co., 305 *W. Lancaster Ave., Wayne, Pa.*



A wide range of lens magnifications, a complete illumination system and a small-size camera permit metal or other material samples to be examined or photographed under optimum conditions.

Designation: OPL Metallograph.

Size: Base, 12 x 12 in.; 18 in. high.

Service: Structural analysis of materials; objective lenses (light background, achromatic) x5, x10, x60, x100, (light background, apochromatic) x20, x60, x100; objective lenses (dark background) x20, x40, x60; projective lenses, x5, x10; ocular lenses (negative) x5, x7, x10, x15, (positive) x10, x14, (compensating) x10, x20; dry examination or by immersion; 8-volt light source operates from 110 or 220 v, 50-60 cycle current; 5 filters; staging table can be moved vertically or rotated about optical axis; 35 mm. film or 2¼ x 3¼ in. plates for photography; base eliminates vibration; grain measurement screens provided.

Design: Standard 8-volt lamp supplies illumination through five-sided indexing turret containing filters —can be elevated to provide transparent illumination; inspection can be made through binocular, adjustable for right or left eye, or ground-glass screen for focusing camera; 35 mm, 36 frame camera interchangeable with 2¼ x 3¼ in. plate holder; lens-to-air surfaces coated.

For more data circle MD 32, Page 175

HELPFUL LITERATURE

FOR DESIGN EXECUTIVES

79. Oil Hydraulic Pumps
Commercial Shearing & Stamping Co.—60-page illustrated catalog H-4 records in charts and tables performance characteristics of PD series single oil hydraulic pumps furnished in ¾, ⅞, 1, 1¼, 2, 2½ and 3-in gear widths. Horsepower input and gallonage discharge are shown through pressure range from 0 to 1500 psi. Output covers delivery from 0 to 50 gpm.

80. High Speed Camera Instructions
Wollensak Optical Co.—Operating instructions for 8-mm, 16-mm and 35-mm high speed Fastax motion picture cameras are found in "Fastax Instruction Bulletin." Cameras are used to record motion continuity of high speed subjects ordinarily invisible.

81. Asbestos Packings
Raybestos-Manhattan, Inc., Packing Div.—Service recommendations, along with descriptions and illustrations, are included in 8-page bulletin on braided and twisted asbestos packings. Standard sizes, standard packages in which each type can be obtained and approximate weights are among data covered.

82. Heat Treating Slide Chart
Carpenter Steel Co.—5 x 11-in. slide chart gives complete answers to such items as heating speed, furnace atmosphere, temperature for drawing and time for drawing. Data on the steel analysis, forging heat, annealing and hardening treatment and other information are included.

83. Hydraulic Valves
Rivett Lathe & Grinder, Inc.—Illustrated and described in catalog section No. 203 are 138 different hydraulic valve models, each in varying sizes. The 28 pages in book offer designers complete file containing listing of every standard hydraulic valve. Working drawings and specifications are included.

84. Wires, Cables & Cords
General Electric Co., Construction Materials Div.—Product designers will be interested in catalog No. 19-470 on wires, cables and cords which gives specifications, construction and applications for all types of wire used in portable tools, lamps, machine tools and other equipment.

85. Metal-Neoprene Washer
Fabricated Products Co.—Applicable wherever a metal and composition washer is used for sealing, surface protection or vibration absorption, Weath-R-seal combination metal and neoprene washers are made in ⅜ to 3-in. diameters as well as in squares, ovals, hexagons and other shapes. Complete data are given in bulletin 513.

86. Metal Plating Facilities
American Nickeloid Co.—Plant facilities for applying and finishing copper, chromium, nickel and brass plating on such base materials as steel, brass, copper, aluminum, tinplate, nickel silver and zinc are outlined in illustrated booklet. Shown are products produced during World War II and include signalling mirrors, first aid kits and bullet jackets. Facilities are offered on subcontract basis.

87. Metal Fabricating
Geuder, Paeschke & Frey Co., Defense Div. Complete metal fabricating, finishing and assembling facilities which are available for subcontract work are shown in detail in 12-page illustrated bulletin "Facilities Available for Military Production." This 15-acre plant is equipped for production, processing, stamping, heat treating, engineering and related operations.

88. Wiring Systems
United Mfg. & Service Co.—How users of Unilectric wiring systems make use of wiring assemblies to speed production, cut costs and obtain uniform quality is described in performance reports from several companies. Six-page illustrated "Dramatic Proof of Unilectric Wiring Know-How" covers such products as refrigerators, furnaces, clothes dryers and food freezers.

89. Metal Protective Chemicals
American Chemical Paint Co.—Intended for fabricators of steel, zinc and aluminum is information on rustproofing, paint-bonding and metal protective chemicals included in 8-page quick reference list. Data on cleaning, preparation and other processes are given.

90. Plexiglas Sheets
Rohm & Haas Co.—Price lists PL-44b, PL-42b and PL-82a are August 16, 1951 revisions covering flat, corrugated and patterned Plexiglas sheets. Lists incorporate changes in size of orders accepted, thickness tolerances and colors.

91. Lubricating Equipment
Universal Lubricating Systems, Inc.—22-page illustrated loose-leaf catalog contains design and application data on hydraulic grease fittings, drain plugs, hydraulic couplers, fitting tools, lubricating guns, engine top oiler and other lubrication accessories. Also described are kits of fittings and tools.

92. Wire Cloth Strainer Design
Michigan Wire Cloth Co.—8-page illustrated "Engineer's Manual of Wire Cloth Strainer Design" presents data on selection of proper grade of wire cloth and shape, size and construction of strainer. Various company services are listed.

93. Industrial Brakes
Wagner Electric Corp.—Improved type HM combination service and parking brake system is described and illustrated in 4-page form EU-106, No. 7. Improvements include elimination of hydraulic pressure switch. Flat rate repair schedule covering conversion of present installations to new system is included.

94. Flexible Shafting
Stow Mfg. Co.—Engineering data on flexible shafting for power drive and remote control applications are found in 12-page illustrated bulletin 515. Many typical applications are shown and complete data is given, including tables for calculating torque and deflection per foot of length.

95. Circuit Breaking Plugs
Pyle-National Co. — Safety and durability construction features of heavy duty circuit breaking series of plugs and receptacles are described and illustrated in 4-page bulletin No. 602. QuelArc connectors are listed in sizes and styles for portable electrical equipment with 20 to 200 amp ratings.

96. Ball Bearing Swivel Joints
Chiksan Co.—"Dimension Data" folder lists sizes and styles of ball bearing swivel joints for pipe line assemblies. Models are available for pressures from 300 to 15,000 psi at 225° F and for 700 psi at 500° F.

97. Eddy-Current Brake Controls
Dynamatic Corp.—Basic electronic circuit employed in control of Dynamatic eddy-current couplings and brakes is described in detail in illustrated bulletin GC-1. Elements of the drive and special control circuits are covered and wiring diagrams of control circuits given.

FOR MORE INFORMATION

on developments in "New Parts" and "Engineering Department" sections—or if "Helpful Literature" is desired—circle corresponding numbers on either card below

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98. Induction Frequency Converters

General Electric Co.—Tri-Clad induction frequency converters are described, and their operation and construction details presented in 4-page illustrated bulletin GEA-5637. Three-phase equipment in ratings from ¾ to 100 kw is covered, and application data, modifications and limitations are given, along with tables of ratings and frame sizes.

99. Vacuum Impregnation

F. J. Stokes Machine Co.—Vacuum impregnation is explained, detailed list of applications is given and equipment used is described and illustrated in 32-page brochure No. 710. Process permits treatment with impregnants of many materials which would be difficult or impossible to treat satisfactorily under amospheric pressure.

100. Wire Rope

Macwhyte Co.—All sizes and construction classifications of improved plow steel wire rope are combined in one large table in 8-page illustrated Monarch Whyte Strand bulletin No. 50-25. Information on how to order wire rope and explanations of wire rope constructions are included.

101. Temperature Conversion

Stevens Mfg. Co.—8½ x 11-in. "Temperature Conversion Chart" provides simple method of converting Fahrenheit to Centigrade and vice versa in range of —70 to 650°. Reverse side of chart tabulates styles, adjustable range, differentials, ratings and other information on line of bimetal thermostats.

102. Punch Press Motors

Howell Electric Motors Co.—Technical data and application information on high-slip high-torque motors for driving punching, forming and shearing machines are presented in illustrated bulletin No. F-2.

103. Electrical Switches & Controls

General Control Co.—Type SY control Promatic timer; types PM and PA post Promatic electronic counters; du-op type DU-8 limit switches; MX, MC, MI and MB foot switches; push button switch type MPB; and type MCT, MCM and MCL lever switches are described respectively in bulletins SY-700, CO-800, DU-400 and FS-200 and data sheets PS and LS.

104. Centralized Lubrication

C. A. Norgren Co.—Illustrated data sheets No. 106 and 109 give details on use of die lubricator on a wire forming machine and of Micro-Fog lubricator on lumber trimming machine. Latter device lubricates chain drives and bearings of 13 saw units.

105. Electrical Conduit

American Brass Co.—Described and illustrated in 4-page bulletin No. C-201 is Sealtite electrical wiring conduit which consists of extruded synthetic covering over flexible metal core. Installation and engineering data are given. Liquid-tight, light and flexible, conduit can be cut to desired lengths.

106. Pressure & Temperature Gages

Rochester Mfg. Co.—Gages that indicate pressure, temperature and liquid level, and ammeters-Tellite signal system which warns of engine malfunction are covered in 8-page illustrated brochure entitled "Rochester Gauges." Dimensional diagrams and specifications are given.

107. Chain Drives

Whitney Chain Co.—To assist in chain drive selection, catalog HD-51 offers simple, quick means of determining interchangeability of various makes of roller and conveyor chains. Data of value in determining proper application of chain drives as power transmission or conveying medium is also supplied.

108. Transformers

Acme Electric Corp.—Company facilities for producing transformers and other electrical equipment components are shown in 12-page catalog MT-188, with emphasis on testing equipment necessary to comply with MIL-T-27 specifications. A complete history of the company is presented and examples of types of products for military, industrial and civilian use are illustrated.

109. Metal Working Aids

E. F. Houghton & Co.—To simplify the selection of products complying with Government specifications, 8-page booklet "Houghton's Government Specification Products" lists these items in the following classes: rust preventives, lubricants, metalworking aids, cutting oils and leather and synthetic rubber products.

110. Pressure & Vacuum Switches

Barksdale Valves—32-page illustrated manual 1MB-1 describes pressure and vacuum actuated switches for industrial applications. Data includes glossary of terms, tabulation of available units based on function and pressure or vacuum range, diagrams for circuit detailing, electrical rating table and operating characteristics of diaphragm, piston and bourdon tube type pressure actuated switches.

111. O-Ring Seals

Arrowhead Rubber Co. — "O-Ring Data Sheets" are offered to designers and users of hydraulic and pneumatic mechanisms to aid in solution of any problems related to O-ring seals. To obtain expert advice, designer fills in form with details of conditions under which seal operates and other pertinent data. Recommendations are forwarded promptly upon receipt of this sheet.

112. Bellows Expansion Joints

Solar Aircraft Co.—Over 78,000 possible combinations of bellows type expansion joints as well as a complete line of aircraft bellows and assemblies are listed in 40-page illustrated catalog. Standard and special bellows assemblies to take up expansion, contraction and offset movements in pipes and conduits are shown. Assemblies range from ¼ to 72-in. pipe sizes for pressures from vacuum to 1000 psi.

113. Brass & Copper Alloys

Bridgeport Brass Co.—To help metal workers to distinguish between copper base alloys, 4-page bulletin "Bridgeport Alloys Properties and Uses" lists 65 commonly used brass and copper alloys along with their composition, properties, forms and typical uses. Industrial designers, estimators and purchasing agents will find folder useful.

114. Clutches & Drives

Twin Disc Clutch Co.—More than 60 applications of friction clutches and hydraulic drives are described in 32-page illustrated Cross Country issue of "Production Road." Performance of clutches, drives, power take-offs and reduction gears in machine tools, boats, pumps, tractors, cranes and hoists, shovels, compressors and hundreds of other machines is cited.

115. Hydraulic Remote Controls

Sperry Products, Inc.—Hydraulic remote controls used for manual or automatic control of various devices in the industrial, automotive, aviation, railroad and marine industries are described in 4-page bulletin 20-106. These self-contained systems operate independently of outside sources of power. They have capacities of 400 in.-lb on pressure stroke and 125 in.-lb on return stroke.

116. Nickel Alloyed Cast Irons

International Nickel Co. — 36-page booklet "Nickel Alloyed Cast Irons" describes eight types of Ni-Resist austenitic nickel alloy cast irons that offer unusual properties. Application and comparative service data are presented to show alloys' utility in withstanding corrosion, heat, wear and low temperature. Photos, properties tables and corrosion data on nearly 400 conditions are given.

117. Copper Die Pressed Forgings

American Brass Co.—To the materials engineer and product designer, 12-page "Anaconda Die Pressed Forgings" booklet provides practical, comparative illustrations to show what copper and copper-alloy die pressed forgings can do and what can be expected of them. Tabulation of physical properties is included.

118. Coolant Filter

New Britain Machine Co.—4-page illustrated folder describes performance adaptability, installation, cleaning, and advantages of model 431 Coolant-Klean filter designed especially for grinder coolants. Design is shown in diagrammatic view. Coolant flow rate averages 15-25 gpm with ¼-hp centrifugal pump and 25-35 gpm with ½-hp pump.

119. Fastening Pin

Prym Engineering Co.—"Flexible Coils: A New Fastening Principle" is title of 4-page illustrated folder which explains and diagrams the working principle of Spirol Pins used to fasten unlike materials such as brass and aluminum to steel, or glass or plastic to metal. Compressing action of spiral enables pin to absorb impact and overload stress. Pin assumes shape of any hole.

120. High Pressure Pumps

Food Machinery & Chemical Corp., John Bean Div.—32-page illustrated catalog "High Pressure Industrial Power Pumps" deals with design, performance and applications of pumps with capacities up to 80 gpm and pressures as high as 6000 psi. Also tabulated are various pump accessories for hydraulic service.

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1	21	41	61	81	101
2	22	42	62	82	102
3	23	43	63	83	103
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5	25	45	65	85	105
6	26	46	66	86	106
7	27	47	67	87	107
8	28	48	68	88	108
9	29	49	69	89	109
10	30	50	70	90	110
11	31	51	71	91	111
12	32	52	72	92	112
13	33	53	73	93	113
14	34	54	74	94	114
15	35	55	75	95	115
16	36	56	76	96	116
17	37	57	77	97	117
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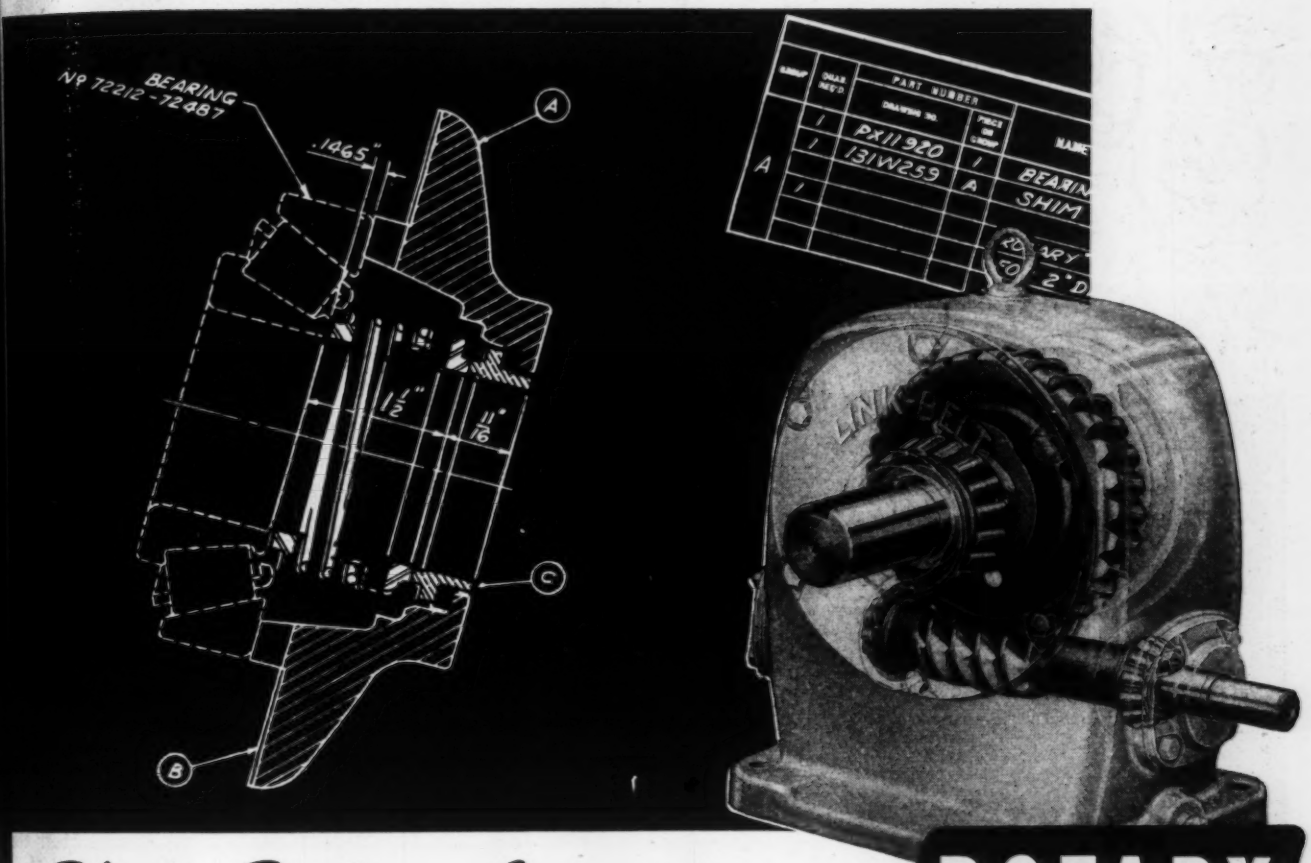

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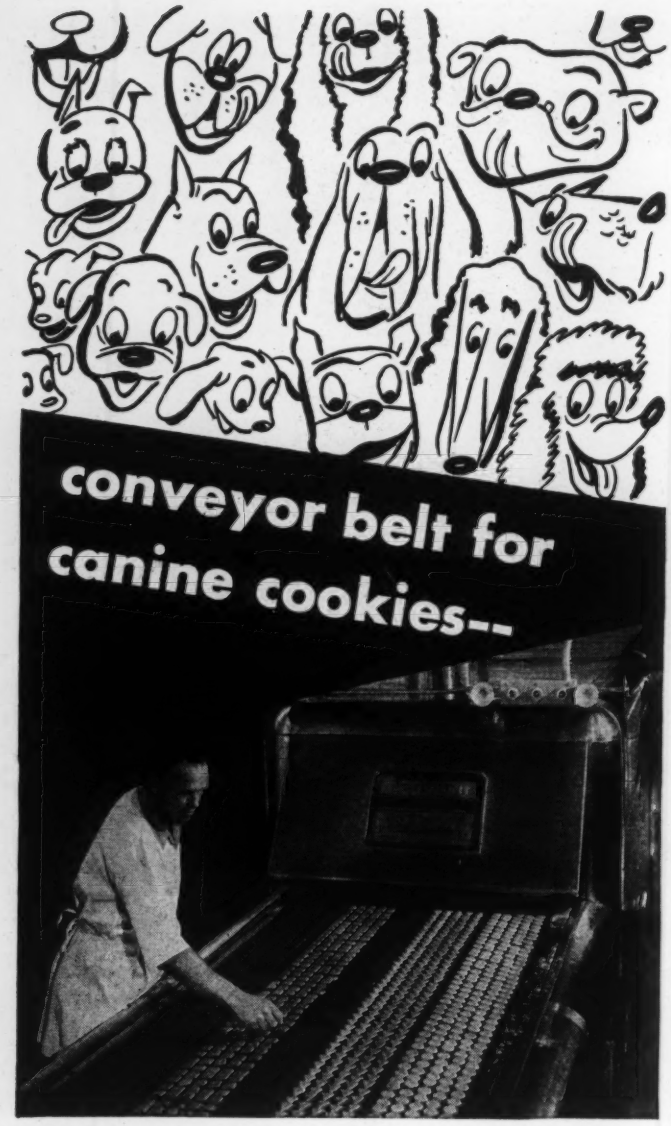

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THE ENGINEER'S Library

Production Processes Their Influence on Design Volume II

By Roger W. Bolz, associate editor, MACHINE DESIGN; *published by Penton Publishing Co., Cleveland; 357 pages, 6½ x 10 inches, clothbound; available through* MACHINE DESIGN, $7.50 *postpaid.*

Today, engineers must be widely conversant with production methods and have more than a passing understanding of producibility. *Production Processes—Their Influence on Design* makes such an understanding possible. By showing the designer how the parts he designs are actually produced, by acquainting him with the processes, and by showing him how to design specifically for production, the book places in his hands the most potent of all tools for reducing costs in terms of equipment, time, labor and materials.

Following the precepts of Volume I, published in 1949, this second volume carries to completion the coverage of major manufacturing methods. Here again, the same uniform treatment of each method is pursued to permit a broad, unbiased analysis of the process, its characteristics and attributes, detail design of parts, selection of suitable materials, and typical tolerances to expect in production.

Following the chapter groupings of Volume I—metal removal, metal forming, metal working and forging, and metal deposition methods—this volume, with eighteen chapters, covers casting, molding, fabricating and treating methods, and brings to a total of fifty-four the production processes covered.

Since few designers or students of design have ready access to intimate on-the-scene studies of processes this down-to-earth set of books will fill a real need. The need for matching the design of parts with the processes used in their manufacture has taken on increased significance in this present period of unprecedented demand for economical production. *Production Processes* comes at a most opportune time to aid designers in meeting the drastic requirements of the era.

□ □ □

Vibration and Shock Isolation

By Charles E. Crede, chief engineer, Barry Corp.; published by John Wiley & Sons Inc., New York; 328 pages, 6 by 9 inches, clothbound; available through MACHINE DESIGN, $6.50 *postpaid.*

Designed to give the practicing engineer a working knowledge of vibration isolation, this book presents the basic mechanics, design and application of resil-

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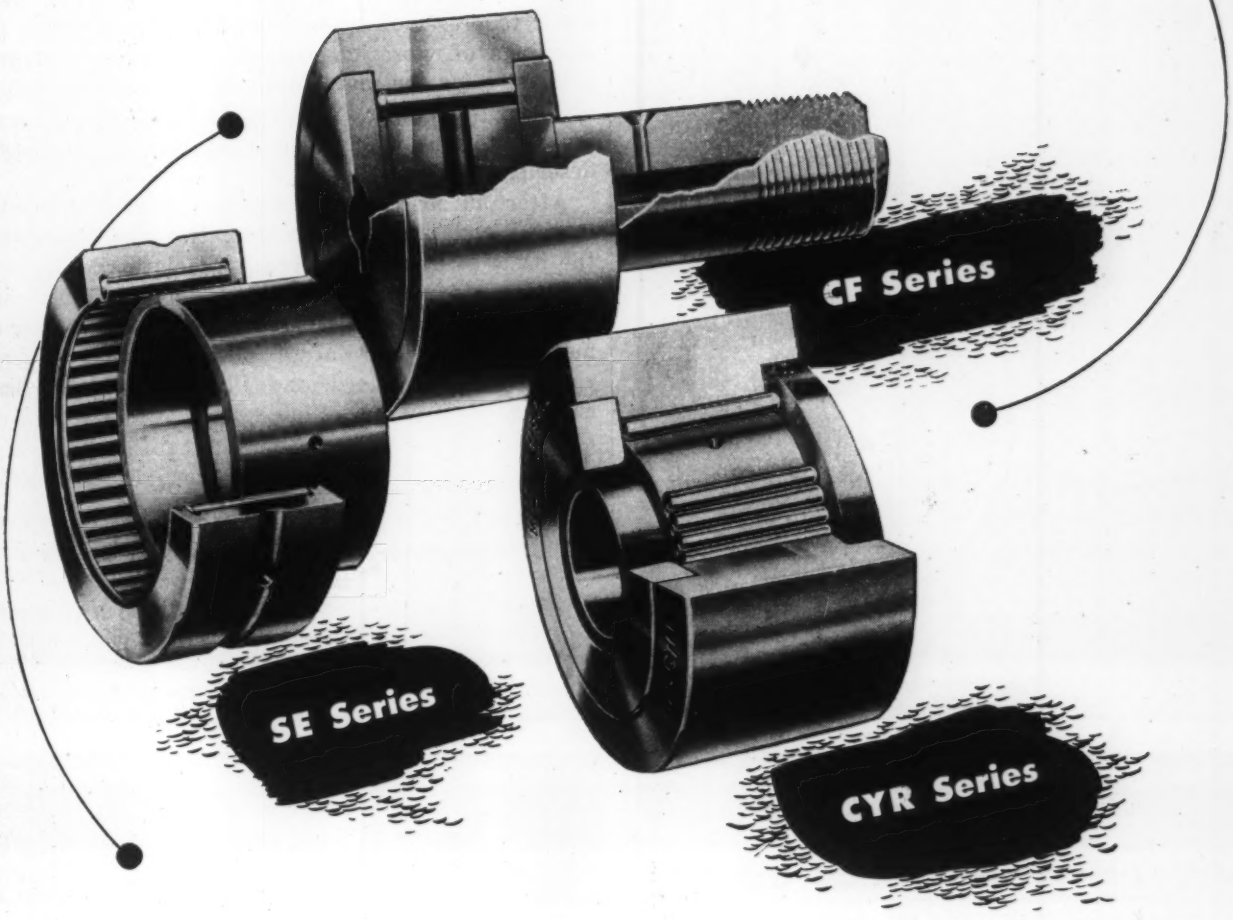

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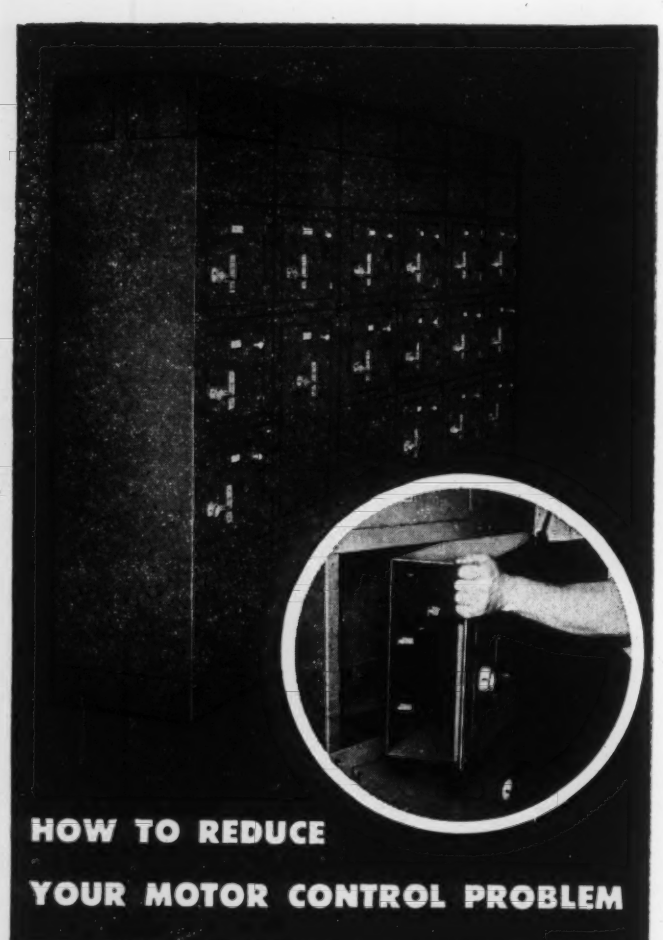

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ient mountings. Portions of the book appeared as articles in MACHINE DESIGN for December, 1950 and January, 1951 under the title "Designing for Shock Resistance."

Physical and mathematical principles of vibration isolators, and how these principles can be applied in solving working problems, are the main subjects. Much of the general theory of vibration is omitted in order to present a more comprehensive study of the workings of vibration and shock isolators. Written primarily for the mathematically skilled development or design engineer, the book nevertheless presents much information of a nonmathematical and purely descriptive nature.

After an introductory chapter discussing mathematical and physical concepts, two chapters review the basic principles of vibration isolation. Nonlinear and damped systems, practical damper design, and sound isolation are discussed next, with a chapter on materials used in isolators following. Specific applications are described and illustrated in the final chapter.

□ □ □

Analysis and Design of Translator Chains

By H. Ziebolz, vice president, Askania Regulator Co.; published by Askania Regulator Co., Chicago; two volumes, 273 and 130 pages, 5½ by 8½ inches, spiral-wire bound with paper covers; available through MACHINE DESIGN, *$6.00 postpaid.*

A systematic approach to the classification of mechanical, hydraulic, electric and electronic devices makes it possible to think of them as symbols rather than as specific apparatus.

After technical devices have been so reduced to logical symbols, it is the author's contention that a variety of solutions to definite problems can be found without the necessity of visualizing a number of individual intermediate steps. This second edition is essentially the same as the 1946 edition, with revisions and corrections. The first volume contains the text; the second contains tables.

□ □ □

Theory of Flow and Fracture of Solids

By A. Nadai, consulting mechanical engineer, Westinghouse Research Laboratories; published by McGraw-Hill Book Co., New York; 567 pages, 6 by 9 inches, clothbound; available from MACHINE DESIGN, *$10.00 postpaid.*

Formerly titled *Plasticity*, this is the first volume of a two-volume revision of the previous work, published in 1931. Emphasizing mathematical principles and mechanical laws governing flow and fracture, the book deals with the deformation of solids, discusses yielding of solids, particularly of metals under simple stress such as bending and torsion, and

analyzes problems concerning elastic, very viscous and ideally plastic substances. Additions to the previous volume include a survey of general conditions causing fracture in metals and reviews of experimental investigations in the yielding and fracture of metals under combined stress.

□ □ □

Nomographic Charts

By C. Albert Kulmann, consulting engineer; published by McGraw-Hill Book Co., New York; 250 pages, 7 by 10 inches, clothbound; available through MACHINE DESIGN, *$6.50 postpaid.*

Ninety-two nomographic charts, giving solutions to many problems encountered in daily engineering work, are included in this volume. Enabling the engineer to arrive at preliminary solutions to problems without extensive mathematical analysis, these charts can reduce routine work, while retaining a moderate degree of accuracy.

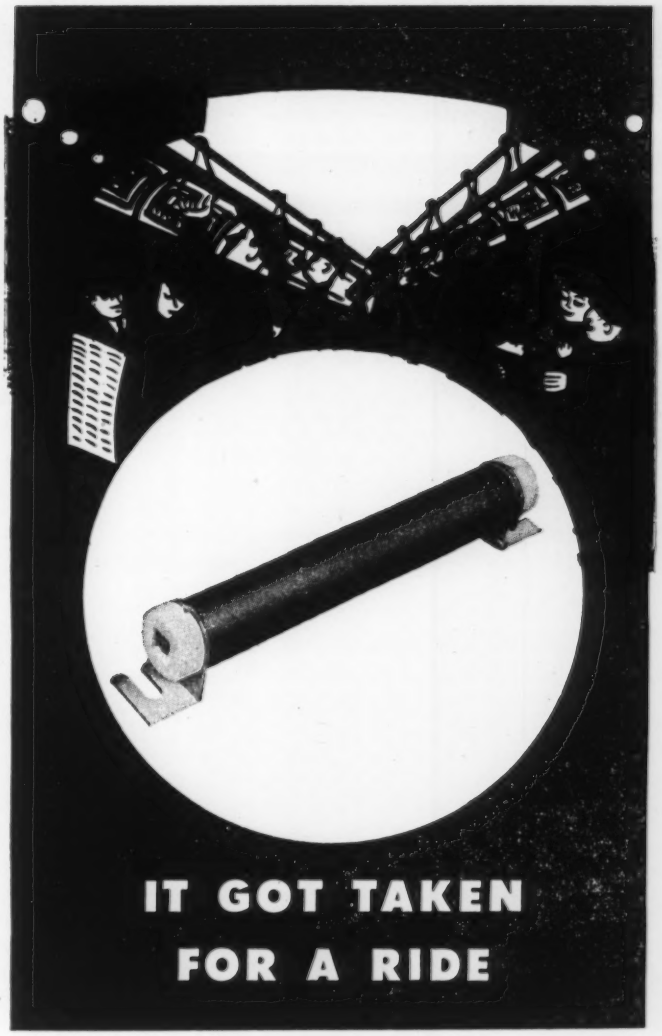
Charts are divided into five sections as follows:

1. Function scales—roots and powers of numbers; reciprocals; circle circumference and area; weight of steel plate—15 charts
2. General charts—reciprocals of reciprocal sums; interest and annuity; properties of rectangles, isosceles trapezoids, right triangles—8 charts
3. Hydraulics charts—water pressure, quantity, head and velocity conversions; weir and orifice discharge; pipe flow, loss and velocity; pressure waves and rise; tank volumes and strength; jet and pump horsepower; hydraulic turbine charts; rainfall—28 charts
4. Mechanics charts—beam and column loading; compression springs; belt dimensions; torsional moment and stress; centrifugal force; pipe loading—12 charts
5. Thermodynamics charts—gas expansion; flow through orifice and pipe; throttling calorimeter; evaporation factor; combustion air and carbon dioxide; heat loss; boiler efficiency—12 charts
6. Electrical charts—voltage drop in conductors; power measurement and factors; equivalent spacing; inductance and reactance; capacitance and susceptance; hyperbolic angle and functions; surge impedance and admittance; voltage and current characteristic factors; vector equivalents—17 charts.

Alignment charts and intersection charts (graphical coordinates and curves) are used, plus combinations of both.

New Standard

Acoustical Terminology ASA Z24.1-1951: Definitions for acoustical terms used in twelve major fields, and six tables have been included in this standard. Of major interest to engineers engaged in acoustical work will be the sections on sound transmission and propagation, transmission systems and components, ultrasonics, recording and reproducing, general acous-



and liked it!

This Ward Leonard Vitrohm bracket terminal resistor was installed in the fluorescent lighting system of the new subway cars for three important reasons.

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tical apparatus and acoustical units. Other sections include hearing and speech, music, architectural acoustics, etc. Copies of this 50-page standard may be obtained from the American Standards Association, 70 East 45th St., New York 17, N. Y. at $1.50 per copy.

Association Publications

NACA Technical Notes: These reports represent the result of investigations carried out at NACA's Lewis Flight Propulsion Laboratory. Each is 8 by 10½ inches in size, paper-bound and side-stapled, and contains complete drawings and illustrations. Among the reports available are:

2378. Automatic control systems satisfying certain general criterions on transient behavior: an analysis developing a rational method of control synthesis starting from arbitrary criterions, and developing an equation for the system that satisfies these criterions

2384. Preliminary investigation of wear and friction properties under sliding conditions of materials suitable for cages of rolling-contact bearings

2394. Effects of design details on the fatigue strength of 355-T6 sand-cast aluminum alloy

2397. Influence of tensile strength and ductility on strengths of rotating disks in presence of material and fabrication defects of several types

2460. Formation of sulfide films on steel and effect of such films on static friction: a study of extreme-pressure lubricants.

Copies of the above notes may be obtained from National Advisory Committee for Aeronautics, 1924 F St., Washington 25, D. C.

American Management Association Series: Each of these 6 by 9 inch booklets includes a group of related papers originally presented at conferences of the American Management Association. Bound in paper covers, these booklets cover:

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195. Mobilizing Production for National Defense—40 pages

197. Planning for Peak Production; with a section on the impacts of the wage freeze—47 pages

198. Materials Problems of the Emergency: Producing for the Armed Services—59 pages

Personnel Series

137. Practical Methods of Management Development—32 pages

140. Tools for Improved Personnel Relations—44 pages

Financial Management Series

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Copies are available at $1.00 each for members and $1.25 for nonmembers from the American Management Assn., 330 West 42nd St., New York 18, N. Y.

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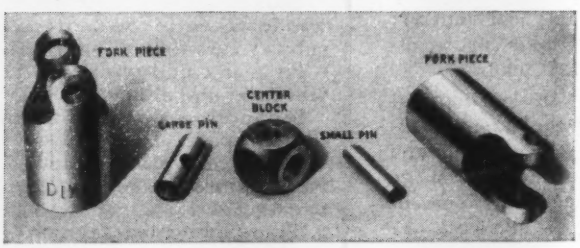

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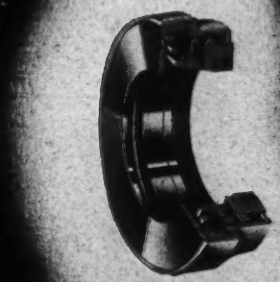

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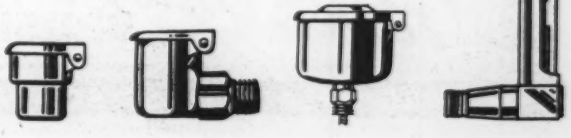

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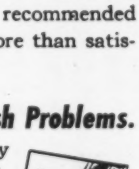

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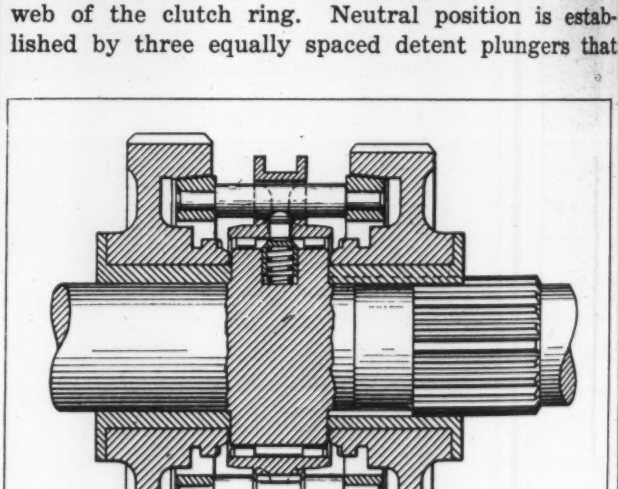
NOTEWORTHY Patents

SYNCHRONIZED POSITIVE CLUTCH ENGAGEMENT while in motion in either direction of rotation is the main feature set forth in patent 2,546,746 assigned to International Harvester by William W. Henning. A dual clutch-unit is illustrated, operation being similar in either direction. The clutching ring is splined to the shaft, and is grooved externally to accommodate a shifter mechanism. Inside hub ends of the clutch gears are splined identical to the shaft, while the inner gear rims are taper-bored to fit synchronizing rings, which are located by a series of spacer pins passing through elongated slots in the web of the clutch ring. Neutral position is established by three equally spaced detent plungers that



engage notches in the center of the spacer pins, and running clearance is thus maintained between the friction clutch surfaces. When the clutch ring is shifted, friction engagement first occurs between the inside rim of the gear and the tapered ring. This imparts rotation to the gear, but the torque reaction tends to cause lag of the synchronizing rings. Diametrically opposite each detent assembly are spacer pins having necked center portions. Normally, the axis of these pins coincides with the center of the web holes through which they pass. When the mechanism lags as happens during gear acceleration, the necked pins move out of alignment with the web holes, blocking further movement and preventing premature engagement of the splined clutch ring with the gear. When the gear speed becomes synchronous to the shaft speed, the ring assembly automatically advances, and the pins again line up with the web holes. Further lateral movement of the clutch ring thus becomes possible, and smooth positive engagement is made feasible. At this stage the spring pressure is

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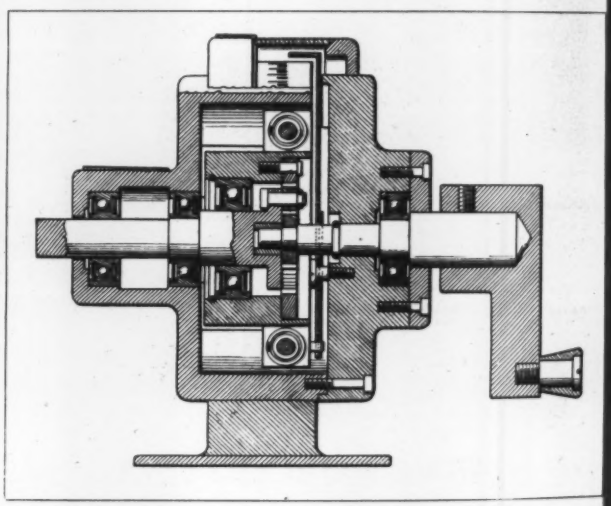
released from the detents, as the result of increased spring compression caused by the crest of the clutch ring splines passing over the spring caps. The synchronizing ring is thereby relieved of pressure contact in the tapered bore during the state of positive engagement. The outward thrust of the spring caps against the clutch ring is intended to prevent accidental self-disengagement of the drive.

CONTINUOUS TORQUE INDICATION of control shaft resistance is the objective of patent 2,550,693. The instrument is portable and adaptable to manual operation, as shown in the illustration. With the output shaft of the instrument coupled to the control shaft, torque required to operate the control in either direction of rotation may be measured. A planetary gear drive connects the input and output shafts, with



planet gears carried on the flanged innermost end of the output shaft, and the sun gear mounted near the end of the input shaft. The ring gear is piloted in a housing which is centered on the output shaft and which is spring balanced in the main frame so as to oppose any rotational tendency. In operation, the resistance of the mechanism being tested causes the ring-gear assembly to react out of the normal position of balance. Corresponding motion is imparted to an indicator hand, permitting measurement of torque to be read directly on a calibrated scale. Patentee Claude Hart has assigned this patent to Collins Radio Co.

COLLAPSIBLE CONSTRUCTION to ease and speed removal of wire coils after winding is the keynote of patent 2,529,185. The core of the winding spool comprises four circular segments which are hinge mounted at the inside end of the quill assembly. One of the flanges is permanently mounted on the quill and the other, which is removable for unloading the finished coil, serves also as an aligning collar for the free end of the collapsible segments when they are

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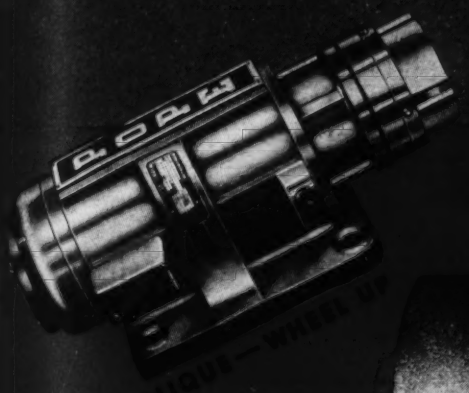

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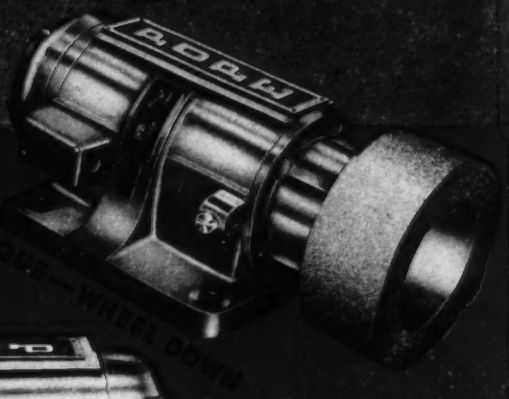

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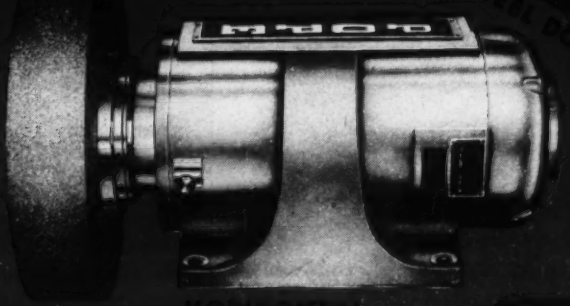

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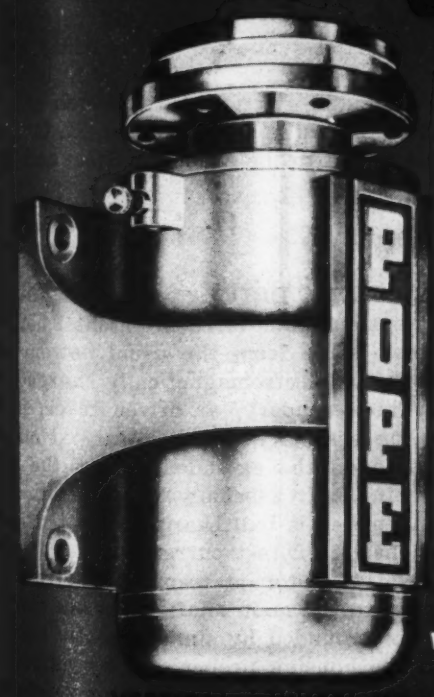

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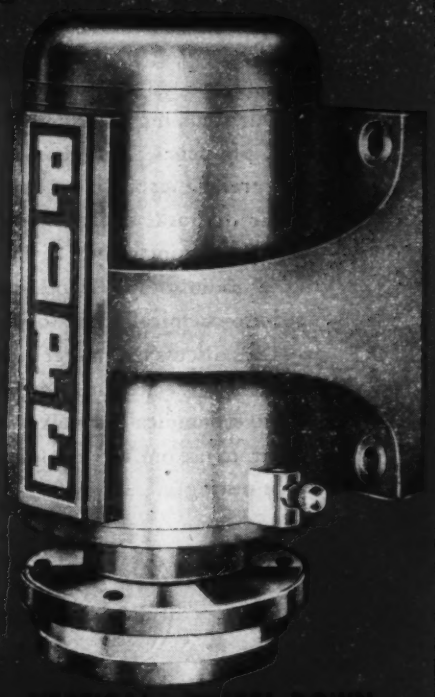

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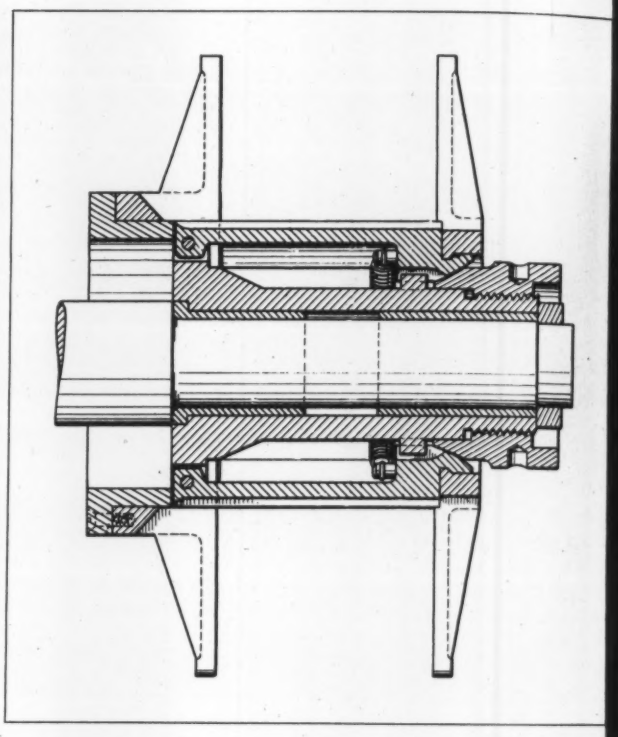
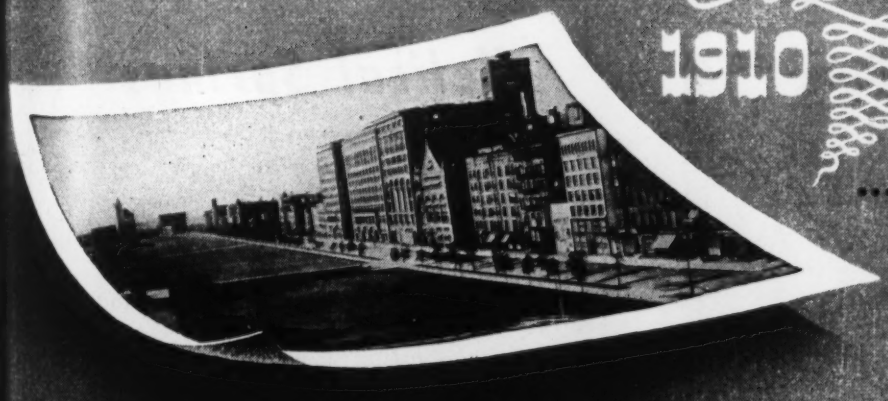


expanded by the tapered takeup nut. The flanges and segments are slotted to permit binding the finished coil prior to removing it from the spool. When the takeup nut is backed off, the segments collapse simultaneously due to an extension spring arrangement inside the free end of the segments. Free ends of the segments are key driven from the quill in order to prevent skewing action while the coil is being wound under tension. Power to the quill assembly is transmitted by an expanding friction clutch which engages the drum end of the quill. The inventor, H. G. Proctor, assigns his patent to the American Steel and Wire Company.

ELECTROMAGNETIC DRIVE of the cooling fan for engine cooling systems is covered in patent 2,559,416. Conventional belt drive from the usual power take-off source drives the electromagnetically charged primary rotor. The secondary, or driven rotor, is the complete fan hub assembly, which is carried on ball bearings mounted on the extended end of the main shaft. The main shaft assembly including the primary rotor and pulley is ball bearing mounted inside a stationary housing. Direct current to energize the coil of the primary rotor is transmitted from the housing terminal to the main shaft by brush contact, the circuit being grounded by similar means between the shaft and the housing proper. In operation, the degree of energization of the primary rotor determines the torque transmitted to the secondary rotor, permitting control of the output speed. Thus, variable input speeds upward from the minimum result in controlled fan speed according to cooling requirements. Maximum energization of the primary coil produces fan speed nearly equal to primary rotor rpm. H. J. Findley, the inventor, has assigned this patent to the Eaton Mfg. Co.



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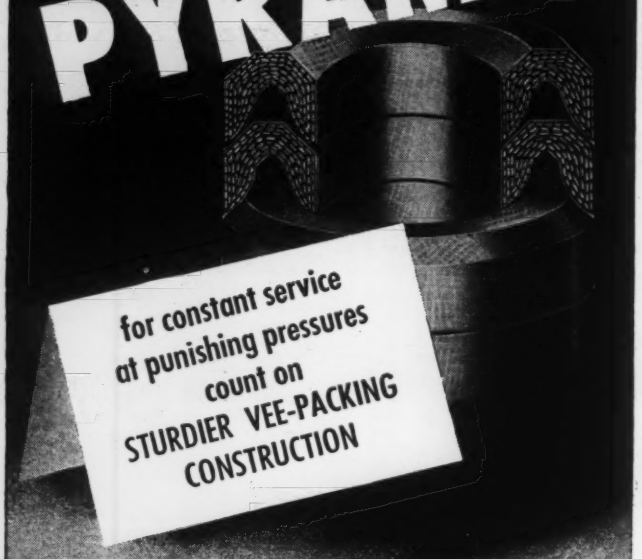
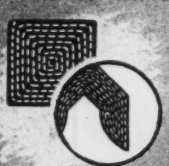


HEAVIER, UNIFORM WALL CONSTRUCTION . . .

No chance here for rupture or wear. Ordinarily, the walls of vee-packings are relatively thin—but the Pyramid's are extra thick, equipped with the strength and staying power to take prolonged service, without letup, in the *toughest* applications.

EACH RING RUGGED AT THE HINGE . . .



No chance here for fraying or splitting. Unlike many vee-packings, which are laminated, the Pyramid is molded from fabric that has been endlessly folded. Thus, no raw edges are left exposed to wear, to break down, and so impair efficiency.

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No chance here for cocking or rolling either—for the cross section of each ring is uniform . . . the Pyramid sits squat and true, has the balance of a square.

And, there's another plus in this balanced design: two-thirds of the lateral packing surface is sealing surface—which means fewer rings per stuffing box.

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Helical Springs

(*Concluded from Page* 138)

from approximately 51,000 psi to 102,000 psi.

To simplify calculations, stress characteristics of other spring materials are referred to music wire at 0.50 stress range and 10,000 cycles—a standard representing the most common requirements in spring design. The maximum shear stresses recommended in design for the standard are called *basic stresses.* In TABLE 1, basic stresses vary from 143,000 psi for 0.004-inch wire to 80,000 psi for wire 0.625-inch diameter.

Load on a helical spring is given by the expression

$$P = \frac{\pi d^3}{8DR_1} S$$

where d = wire diameter, inches; D = mean coil diameter, inches; R_1 = Wahl stress concentration factor (a function of spring index D/d); and S = shear stress, psi, produced by the force P, lb. Solution of the formula gives the highest spring load P for a helical spring of given wire diameter d and mean coil diameter D with music wire at 0.50 stress range and 10,000 cycles.

To obtain the maximum recommended shear stress for any of the eight most common spring materials at 1.0, 0.75, 0.50 or 0.25 stress ranges and 10^3, 10^4, 10^5 or infinite number of operating cycles, basic stress is multiplied by the correction factor given in TABLE 2.

The maximum recommended shear stresses obtained from TABLES 1 and 2 are used by spring designers not merely to satisfy their professional desire for precision but to produce the most economical spring design for specified operating conditions. The wire diameter based on a proper design stress is the smallest—and least costly—wire size that will do the job properly. Design stresses from these tables may either be incorporated into design procedure or consulted to check design based on nominal stresses.

Grease Testing Machine

TO ANALYZE performance of greases in ball and roller bearings over a wide range of temperatures, research scientists of the Texas Co. have developed a grease testing machine that simulates actual service conditions. By observing grease samples in the machine during test—under high-speed stroboscopic light—it is possible to determine changes in quality, texture, consistency and color.

The machine consists of a high speed motor-driven shaft which operates a single-shielded ball bearing encased in an electrically heated oil bath. Temperature of the bath can be regulated from room temperature to 300 F and higher. Test procedure starts with a charge of 5 grams of test grease to the bearing. Visual observation of the grease sample is made at 25 degree increments in temperature under stroboscopic light while the machine is running at 3450 rpm.

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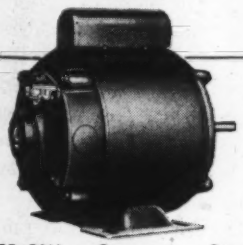
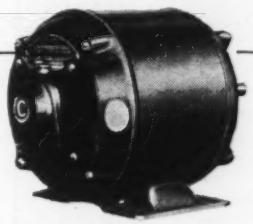
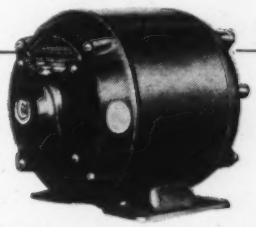


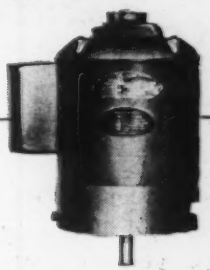
TYPE CSH — Capacitor Start Induction Single Phase Motor suitable where high starting torque and normal starting current is satisfactory.



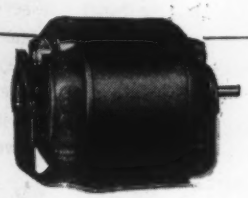
TYPE SP — Split Phase Induction, Rigid Base, Single Phase Motors suitable for light starting duty.



TYPE SC — Squirrel Cage Polyphase Motor built in fractional sizes for all torque requirements.



JET PUMP MOTOR—Capacitor Start Single Phase Motor available in sizes for practically every jet pump application.



TYPE SP — Split Phase Induction, Cushion Base, for quiet operation.

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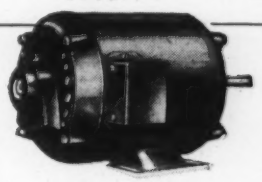
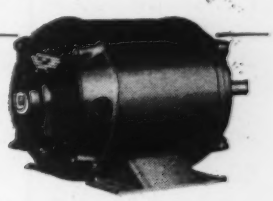


TYPE RS — Repulsion Start Induction Single Phase Brush Lifting Motor suitable for applications requiring high starting torque and low starting current.



TYPE DM — Direct Current built in sizes and ratings for applications where direct current is available or its use desirable.

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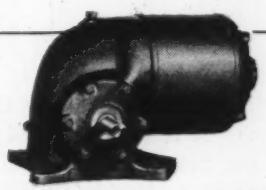

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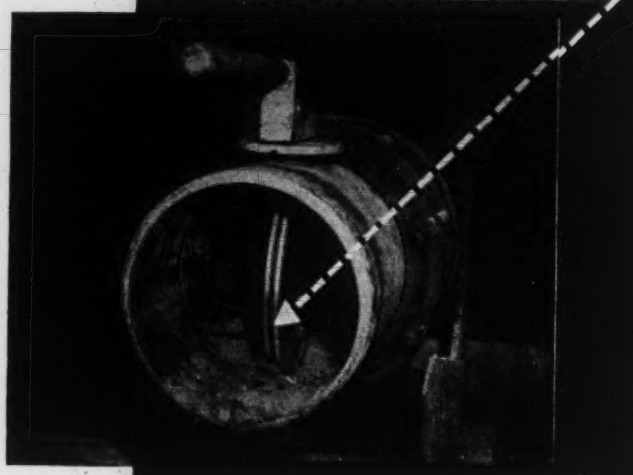

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Adhesives

(*Concluded from Page* 101)

semblies of this character. Metal to metal, wood, ceramics, or plastics assemblies are achieved in this manner. Because it is more of a decorative nature, rather than structural, the stronger thermosetting bonding agents, which require long curing times, are not necessary.

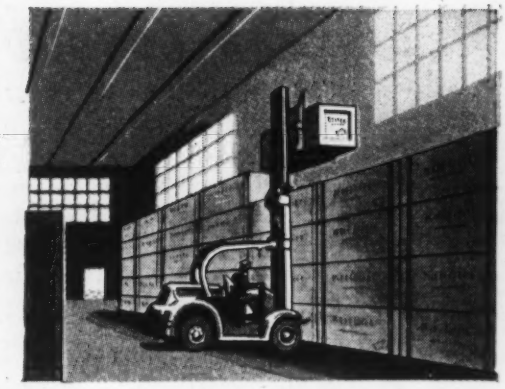
5. *Metal foils to nonmetallics for electrical conductivity:* An important requirement by manufacturers of electronic apparatus is the design of printed electrical circuits. One form which has found wide acceptance, commences with a thin copper sheet bonded to a nonmetallic surface. A strong, permanent bond is essential. The circuit is printed in the copper sheet with the aid of a stencil, which applies an agent to resist etching. The untreated copper is etched off, leaving the required circuit firmly embedded on the nonmetallic. Radio circuits, proximity fuses, and guided missiles are making use of these principles.

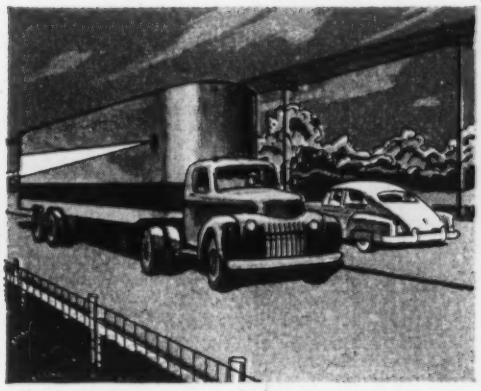
6. *Rubber-metal assemblies for vibration absorption:* Several important high-temperature setting adhesives formulated from synthetic rubbers or chlorinated rubbers are available for promoting rubber to metal assemblies. Full utilization of rubber compounds for vibration absorption becomes possible when mechanical bonding devices are supplanted by adhesives. A representative assembly for vibration absorption or damping is suggested in *Fig.* 13. Torsional and shear stresses developed are resisted by the adhesive bond as well as the rubber.

In connection with the bonding of vulcanized rubber parts it should be noted that best results are experienced when a pretreatment is given to the rubber. One well-known treatment entails the cyclization of rubber by concentrated sulfuric acid. This requires contact of the rubber with the acid for several minutes. The rubber will acquire a crazed surface which, after washing to remove excess acid, may be bonded satisfactorily to the opposing surface. There are other alternatives to this method, and it is suggested that the designer consult with adhesive manufacturers for individual particulars.

Correct use of modern adhesives provides numerous new possibilities for the machine designer. Assemblies can be simplified in some cases and physical benefits improved in others, with permanent and satisfactory results, when the correct adhesive is selected for the job.

"It is not machines that are putting men out of work—it is the *lack* of them. As manufacturers buy better machines, they cut their costs. As they cut their costs under the spur of competition, they reduce their prices. As they reduce their prices, more people can afford to buy their products, sales go up, and employment goes up. That is the way jobs are created."—L. D. McDonald, *vice president, Warner and Swasey Co.*





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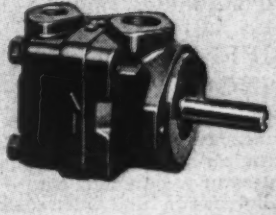

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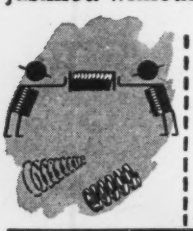

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Linkage Layout

(*Concluded from Page* 110)

that the trace of the second linkage, in the unit square, is made up of points $[g_N(x), f_N(x)]$. A graphical construction for the same purpose is shown in *Fig.* 11; by using deviation-curves the vertical scale can be expanded for increased graphical accuracy. In this figure, the uppermost curve is the deviation for the desired function $f_N(x)$, the lower curve is the deviation of the first linkage, and the locus of Point 4 is the deviation of the second linkage. In the geometrical construction, lines 1-3 and 2-4 are vertical and 1-2 and 3-4, are both parallel to $A\text{-}A' \times A$ and A' are points indicating equal numerical values on the deviation scale and the normalized input scale, respectively.

In designing linkages in series, it is efficient to select for the first linkage some linkage whose output is accurately known and to design the second linkage to fit the calculated (or graphed) trace. To make this design simple, a first linkage should be chosen which leaves a tractable second trace (for example, a smoothly-curved trace with a deviation around 0.2), and whose output range is a convenient input range for the second linkage. After a little experience, it is rare to choose a first linkage which leads to an intractable trace for the second linkage. If good results are not obtained after several trials, it is usually wise to use a correcting cam in one of the linkages.

With a small amount of practice, the machine designer will find these linkage-design methods as useful as we have found them in our work. He may incorporate many improvements and short cuts of his own for particular cases. These methods will not allow design of simple linkage systems to reproduce any given curve but they will suffice in a great many cases. There are many other linkages that can be applied to certain motions; for instance, Bennett and Goldberg[8] linkages can be used. One of these resembles a four-bar linkage whose input and output shafts are skew in space. A large number of articles on linkages and calculating linkages, by Russian authors, have been reviewed in *Mathematical Reviews* during the past few years. Among the authors are Artobolevskii, Bloh, Byhovskii, and Cerkudinov who appear to devote major effort to the subject.

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1. Antonin Svoboda—*Computing Mechanisms and Linkages*, McGraw-Hill Book Co. Inc., New York, 1948. (Massachusetts Institute of Technology, Radiation Laboratory Series, Vol. 27.)
2. Svoboda—Pages 110-11.
3. *Atlas of Some Harmonic Transformers*, an atlas of 73 traces compiled for the HT linkage with rotary input and slide output. Ozalid copies of this atlas, on 11½ by 17-inch sheets, are available on request to the authors at the cost of reproduction (approximately $10.00.)
4. John A. Hrones and Geo. L. Nelson—*Analysis of the Four-Bar Linkage*, 730 charts, 11⅛ by 17¼ inches, John Wiley and Sons Inc., New York and Technology Press of Massachusetts Institute of Technology.
5. Svoboda—Ibid., Pages 217 ff.
6. Svoboda—Ibid., Pages 145-165.
7. Svoboda—Ibid., Chapter 7.
8. Michael Goldberg—"New Five-Bar and Six-Bar Linkages in Three Dimensions," *Transactions of the American Society of Mechanical Engineers*, Vol. 65, No. 6, August 1943, Pages 649-661.

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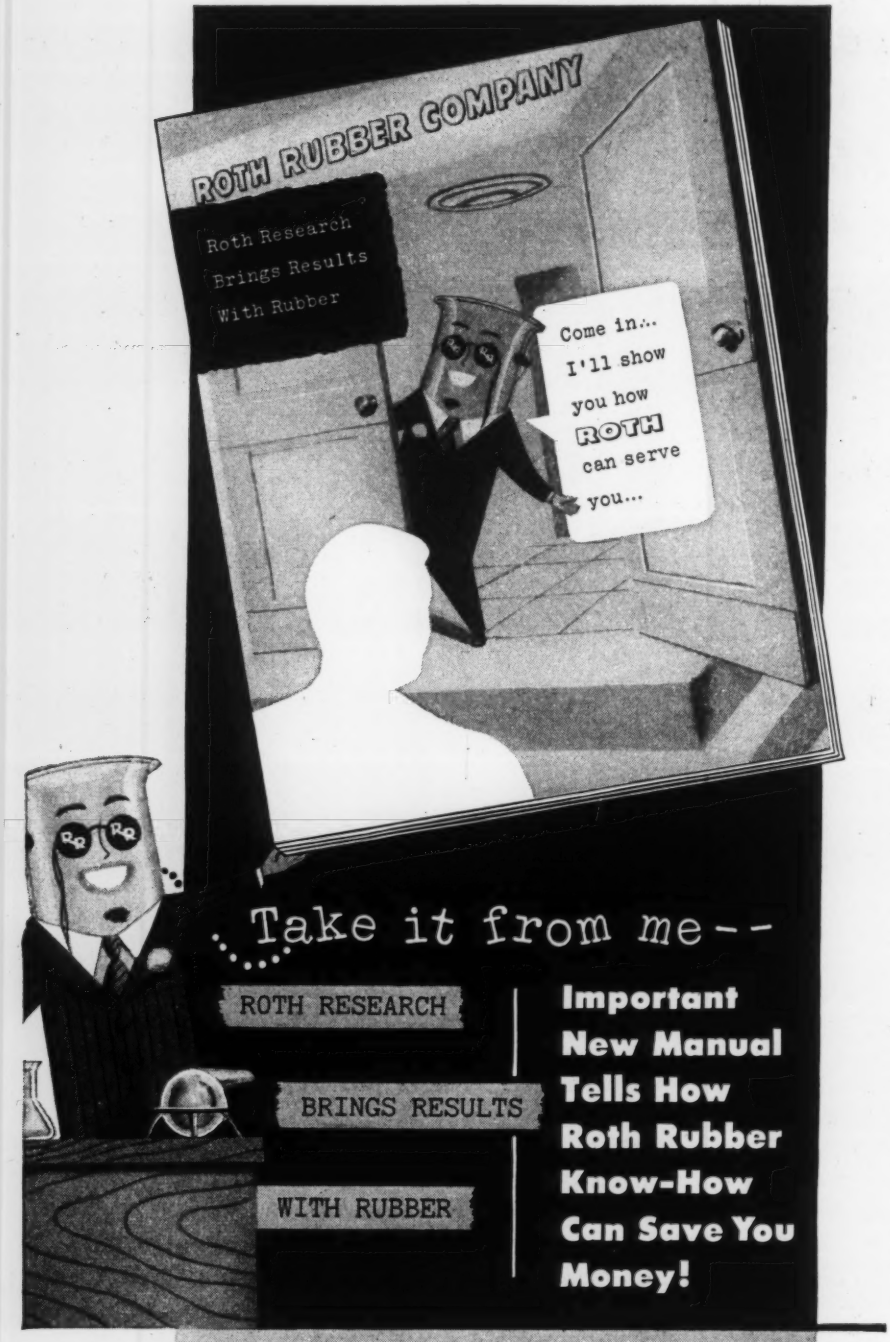

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PROFESSIONAL VIEWPOINTS

". . . should be assigned to file clerk"

To The Editor:

The article "Evaluating Engineers" in the June issue of MACHINE DESIGN was called to my attention by the librarian of a business firm in the East and also by the immediate past president of the Special Libraries Association. I read it with great interest. Apparently there has been as much mystery about job evaluation for engineers as for librarians.

This study without doubt should do much to help the world understand the work of creative engineers. It was a shock, however, to see the very few factors and the relatively low ratings given to those assigned to the librarian. Could it be that the person holding the position in the firm surveyed had so few of them, or haven't they been recognized? There are firms who designate as librarian a person whose sole function may be to file reports sent for safe-keeping. Possibly such was the case. Maintaining up-to-date and orderly files of material is certainly one of the functions of a library, but this should be assigned to a file clerk rather than to a professional librarian.

Librarians are entrusted with the sources of information and records of experience upon which action and judgment may be based. They must *know* these sources in order that their customers—whether they be the research or other personnel of a private organization, faculty or student in a university, or one of the public—may be apprised of their existence. That constitutes the *creative* part of their work. They must discover sources of information, acquire them, learn their contents, determine their validity, organize them for ready use, and correlate them to the need presented, and present them. Sometimes they must abstract them, digest them, and/or translate them. In some instances they hold administrative positions and must take responsibility for selection and training of their staffs.

The profession of librarianship has made great strides in the last few years and continuous study is being made by many librarians and by library school faculties to improve curricula and establish standards which will make the contribution of librarians of increasing value to their firms and communities. For instance,

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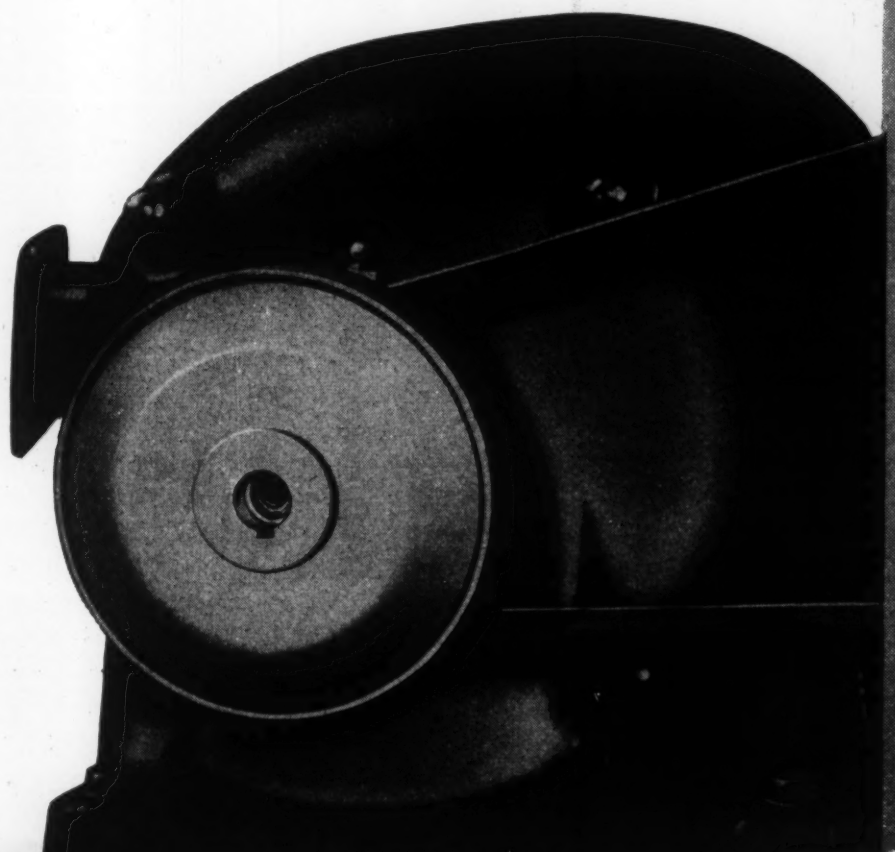

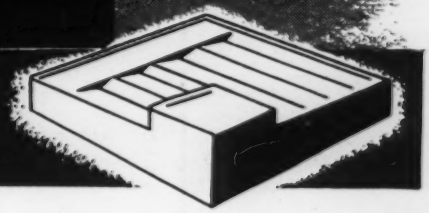

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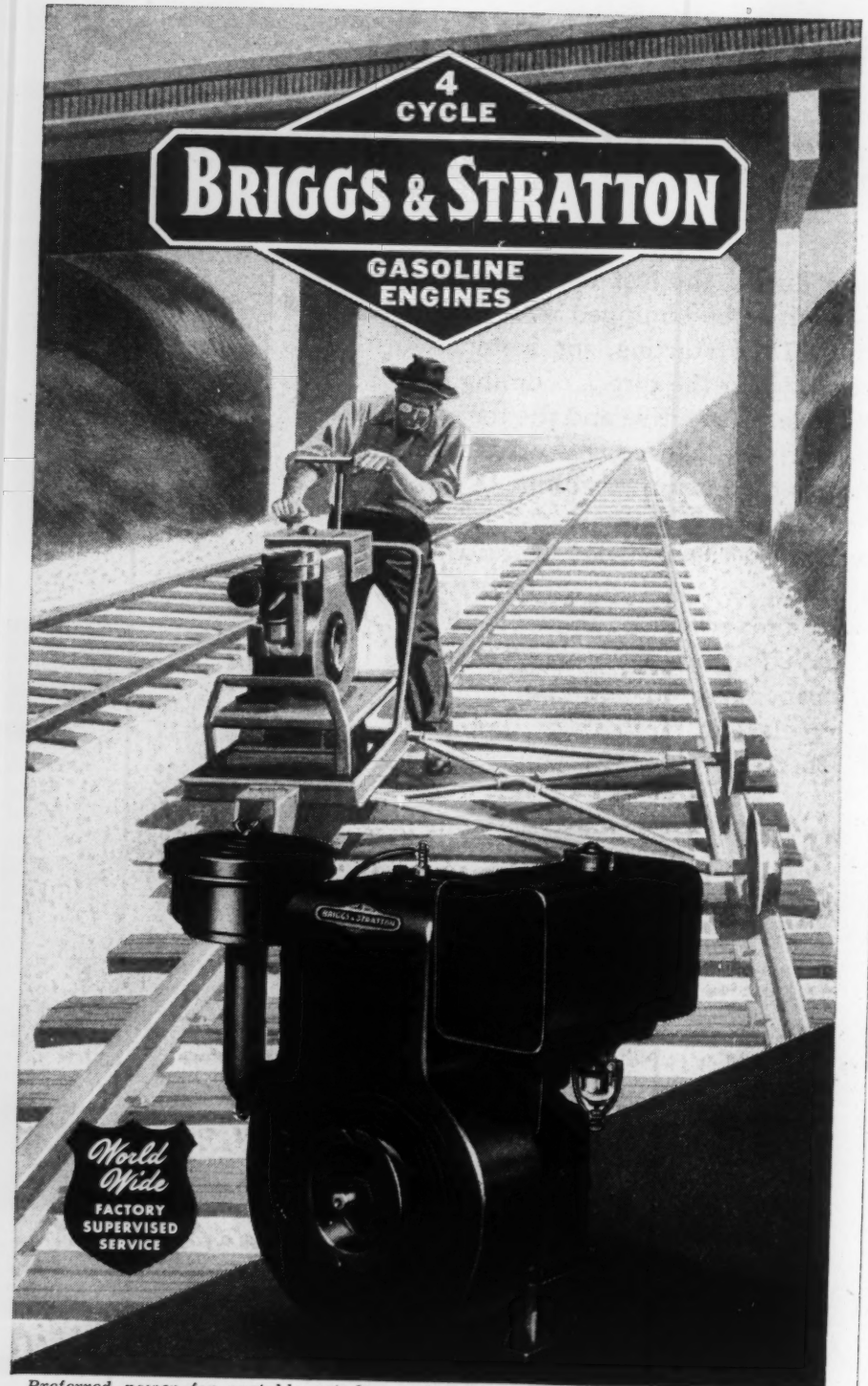

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recently the research librarian of a firm was promoted to advertising manager. When his promotion was announced, the president pointed out, "This job will merely be added to the duties now performed as head research librarian." In another instance the librarian was made an officer of her bank and continues as librarian with full officer status.

Associations of librarians, and there are over 200 of them, including the Special Libraries Association, American Association of Law Librarians, Medical Library Association, and American Library Association, have been concerned with establishing standards for their respective fields. Accredited library schools, which are institutions for graduate study and have courses ranging from one to three years beyond the four-year liberal arts college course, are similarly concerned with turning out a professional product!

I know that far too often a person is appointed as librarian who does not measure up to the standards set. This is because employers do not understand the nature and potentialities of library work. The situation is improving—but it still has far to go. More careful use of the word "librarian" for library reference, research, administrative, or executive work, and "file clerk" or other designation (translator, abstractor, etc.) for other jobs would help all concerned.

For your interest I have noted following the factors used in this job evaluation study and have tried to indicate the manner in which they would apply to a librarian in an engineering firm on the basis of accepted professionally recognized standards.

Skill

Academic Training: Four-year liberal arts college. One year—*minimum* graduate study in accredited school of librarianship.

In-Service Training: In an engineering library or engineering or technical department of a large public library under qualified supervision. Before taking assignment as librarian some opportunity for becoming acquainted with company procedures is essential.

Resourcefulness: Highly important for a librarian who serves a firm adequately. Such a person should be resourceful concerning availability of material which may be outside the firm in places or in forms the engineers may not know about. Must know, too, how to adapt what is available to what is needed. (May need information concerning a certain experiment whtich was not reported in a periodical or proceedings. Librarian should know how to find out where the experiment was performed, who worked on it, what the present status is, whether an unpublished report can be located.)

Power of Visualization: Avenue of approach to a problem very important to attain end results.

Adaptability: Librarian needs to be able to adapt himself and get along with all the personnel in a firm or department—from president to janitor.

Analytical Power: Nowhere could it be more important. Librarian is called upon to produce documents, reports, etc., frequently on the most minute bits of identification.

Knowledge of Prior Art: If experienced as suggested under "In-Service Training" this

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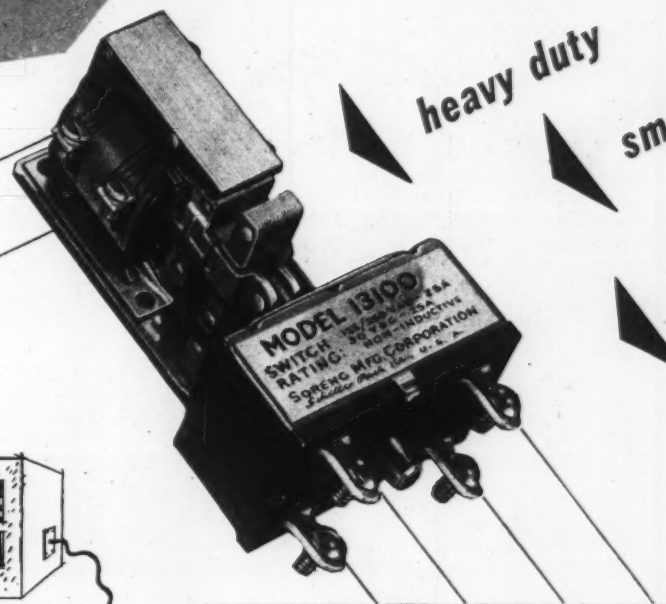

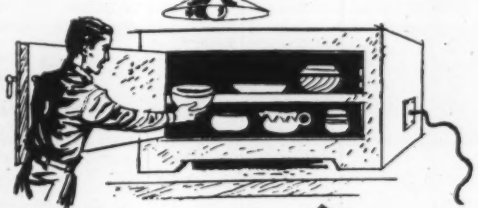

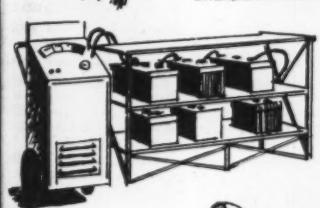

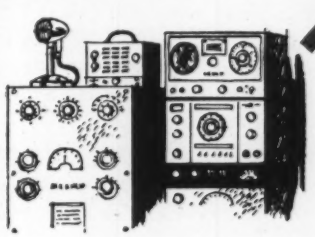

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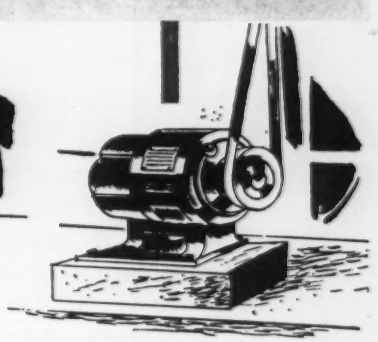

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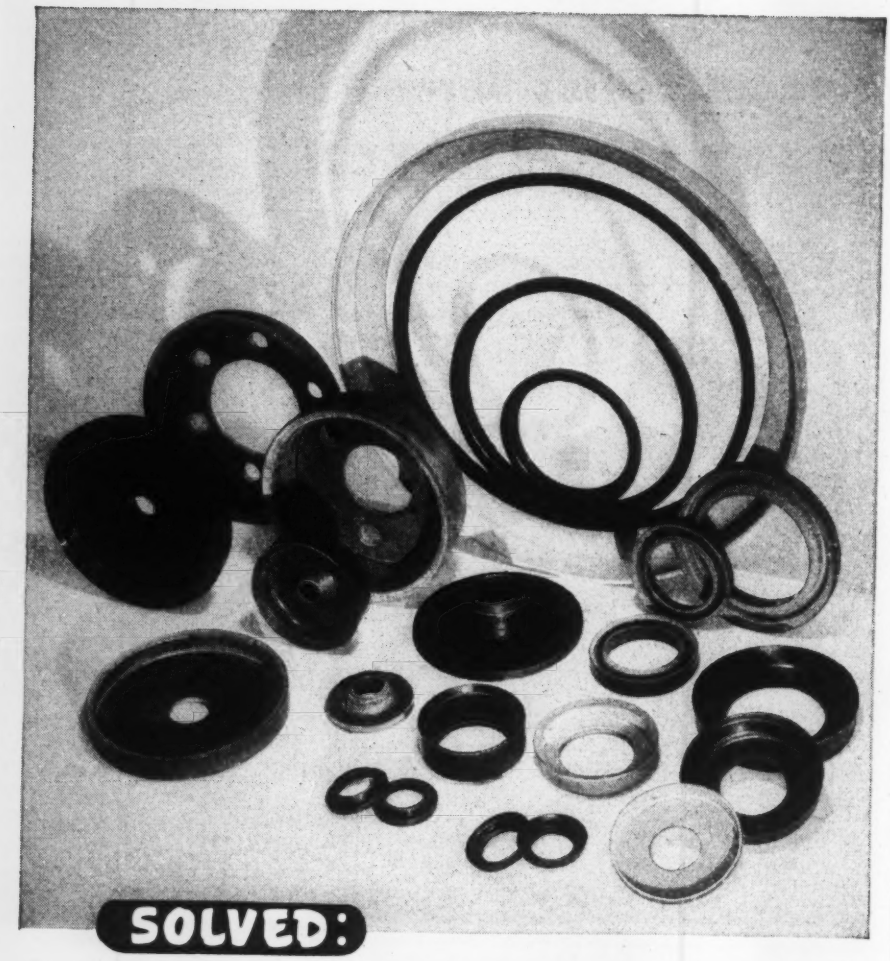

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factor would be almost automatic.

Ability in Organization: Organization of work is essential—whether it be searching answers to spot reference questions, planning time for extended research which might involve conferences outside the firm.

Power of Expression: Needed in dealing with clientele. Must be able to make clear what is covered in the material presented. Often must abstract, digest, or translate data as needed.

Personality: Extremely important for librarian to be approachable, enthusiastic, helpful. Librarian's work is of a *service* nature—requires intelligence and know-how but without personable qualities would lose much of its value. Even as in creative engineering it requires many of the qualities of salesmanship.

Dexterity: Mechanical dexterity not too important for the reference and research librarian though he may be called upon to handle some mechanical research equipment such as microfilm readers, sorting devices, typewriters, comptometers, and filing equipment.

Effort Intensity

Mental Effort: This ranks very high. All reference and research requires mental effort and knowledge based on training and previous experience.

Mental Visual: Of top importance. Librarian must attack problems of reference and research with a clear mental picture of what is needed even though, as is often the case, the request is presented in vague terms.

Accuracy: Very important. Librarian must supply references *exactly* and must indicate the extent to which they are applicable to the problem for which information was requested.

Manual: There are situations in which the library is placed in such cramped quarters that it is necessary to work in uncomfortable physical positions. This depends upon the individual library.

Formulation of Policy: In executive positions the librarian in co-operation with the head of a firm naturally must formulate a library policy which will serve the purpose for which the library was created.

Supervision: If library has more than one staff member this factor would be important.

Training: Must take responsibility for training library staff.

Personnel Requirements: As presented in the Chaffe study this factor might be insignificant so far as library is concerned. But if the project were a huge one—like the Atomic Energy Project in Tennessee—the librarian might conceivably need to take responsibility for library personnel in the same manner as the engineers would for engineering personnel.

Personnel Status: Librarian would have to take responsibility for rating and appraising work on the library staff.

Company Property: Library materials—periodicals, research reports, treatises, etc.—often irreplaceable and in a firm many may be confidential. These as well as the equipment in which they are housed and equipment provided for their use—tables, machinery, etc., are responsibility of the librarian.

Client Property: Frequently librarians borrow materials from other firms to serve their own clientele. These likewise must be carefully guarded.

Health & Safety: Librarian must take responsibility for this in so far as health and safety of library staff are concerned.

Inherent Personal Qualities

Self Confidence: To a healthy degree this is essential.

Respect for Perfection: Library work involves many of the duties of an executive secretary in that it requires considerable original correspondence in answering questions, investigating sources, acquiring materials. This requires perfection in these fields of activity. Beyond these the same degree of perfection is necessary in quoting or citing references, giving information over the phone, etc.

Capacity to Receive Criticism: Librarians must be able to "take it!" Often a client is "certain" of material which actually has not yet been published or issued in the form needed. What librarians must "take" from some such requires a shell of steel with inner resources to keep at it with equanimity and poise, until the question is settled satisfactorily. Objective, impersonal, unemotional attitude must be combined with enthusiasm, interest, and exactitude—paradoxical as this may seem!

Ethical Honesty: Needed as in any professional work.

Spiritual Honesty: Same as in ethical honesty.

Endurance: Same as for any other creative project. May need to put in many extra hours

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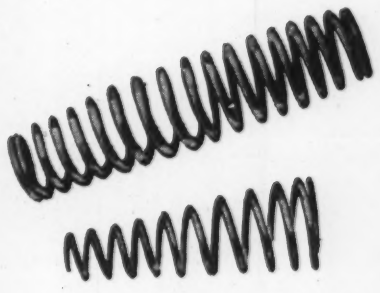

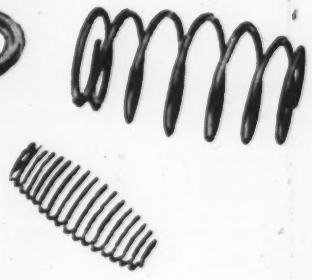

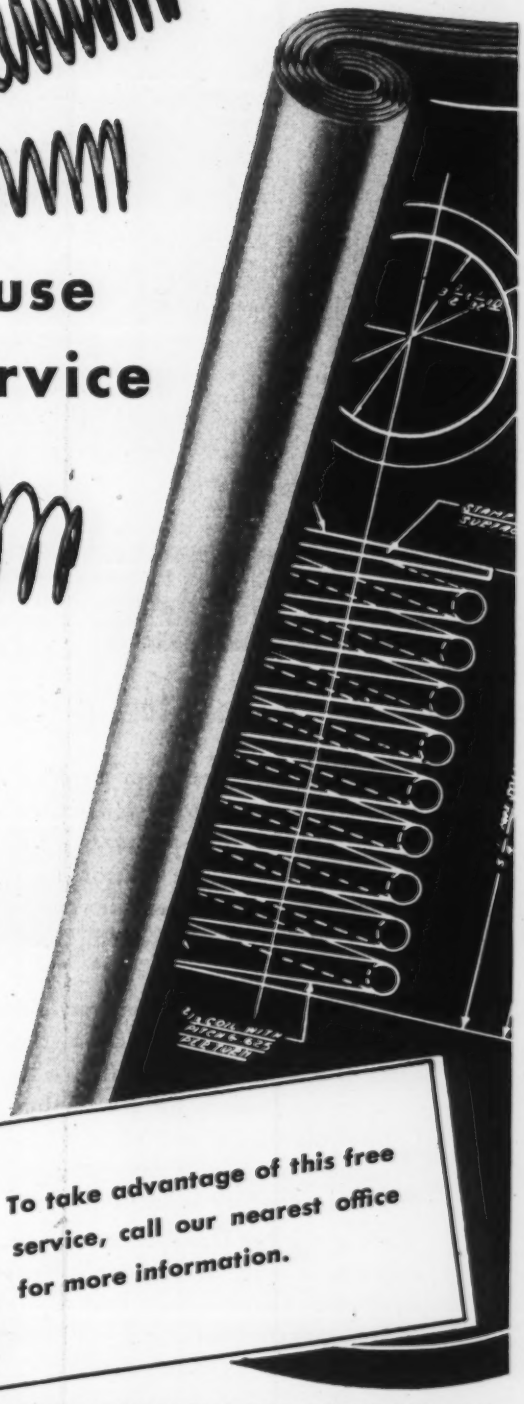

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—ROSE L. VORMELKER
Head, Business Information Bureau
Lecturer, Special Libraries
Western Reserve University
Cleveland, Ohio

". . . would be re-evaluated upward"

To The Editor:

I am pleased to have the comments of Rose L. Vormelker regarding the evaluation of the position of librarian in MACHINE DESIGN. The librarian of the American Optical Company at Southbridge, Mass., has written in the same vein and I have no good defense for that low evaluation..

Here is the background of that evaluation and which should have been described in my article:

At the time the evaluation program was undertaken, a librarian position had been created and filled for only a short time. At the outset, the librarian's duties were confined to the maintenance of subscriptions and the distribution of technical publications among the engineering staff, and the contemporary evaluation considered only these low-level duties.

At the same time, however, we visualized rapid growth in the importance of the position as the librarian could become acquainted with our work, and we asked her to develop and recommend the policy and procedures which, in her judgment, would make her position of greatest value to the organization. It was understood that the position of technical librarian would be re-evaluated upward when the policy and procedures had been finalized.

Upon finding its natural level, the position should, I believe, evaluate in the area about one-third of the total available points or more, depending upon the ability of the incumbent. It seems to me that any creative technician can be far more effective when a librarian searches, locates, interprets, digests and brings to his attention pertinent and timely information bearing upon his current problems. As you say, however, the potentialities have yet to be fully understood and it is well that your profession strives to expedite that understanding.

—RANDOLPH W. CHAFFEE

". . . 34 factors . . . a large number"

To The Editor:

Many thanks for sending to me the monograph on "Evaluating Engi-

neers". Since the middle of April we have been engaged in developing a performance evaluation procedure for use with engineers and other technical personnel employed in Hamilton's Research Division. This procedure will not be a graphic type of rating scale, such as described by Mr. Chaffee in his article, but rather, a performance report form constructed in accordance with the recently-developed "forced choice" method. The primary purpose of both a graphic rating scale and a forced choice performance report is largely the same in this instance, I presume—namely, to obtain a trustworthy, quantified measure of engineering and technical performance. In our particular rating situation we also need a procedure that will enable us to counsel with the technical employee after his performance has been reported—our objective in this latter instance being to encourage the self-development of enginering and technical personnel through a discussion of the evaluation findings and through improved interpersonal relationships between subordinate and superior.

With respect to Mr. Chaffee's article, 34 factors in either a job evaluation plan or a rating scale is quite a large number upon which to expect human judgment to render *independent* evaluations. I would suspect that the intercorrelations among the ratings on the individual factors are quite high, so high that the ultimate overall evaluation can be achieved with a much smaller number of factors. Recent findings in a field of statistics known as factor analysis have offered substantiation for such. I don't know enough about job evaluation plans to comment on the method by which Mr. Chaffee compared his job factors in ranking them, and the procedure by which the maximum values were assigned to the various factors. This, of course, is the point where most of the job evaluation plans are open to question, and rightly so; in the final analysis the validity of any plan is limited by the nature and seriousness of errors introduced into it through subjectivity and arbitrary elements. However, the author acknowledges this point in his last paragraph on Page 153.

A number of the 34 factors comprising Mr. Chaffee's rating scale for "assaying creative performance" appear to be somewhat overlapping and represent nuances to me; this, of course, strikes at the question of whether a rater can clearly differentiate among them as he makes his judgment of each. Moreover, in a graphic rating scale such as Mr. Chaffee's, the rating supervisor is being asked to *rate* his men on "fac-

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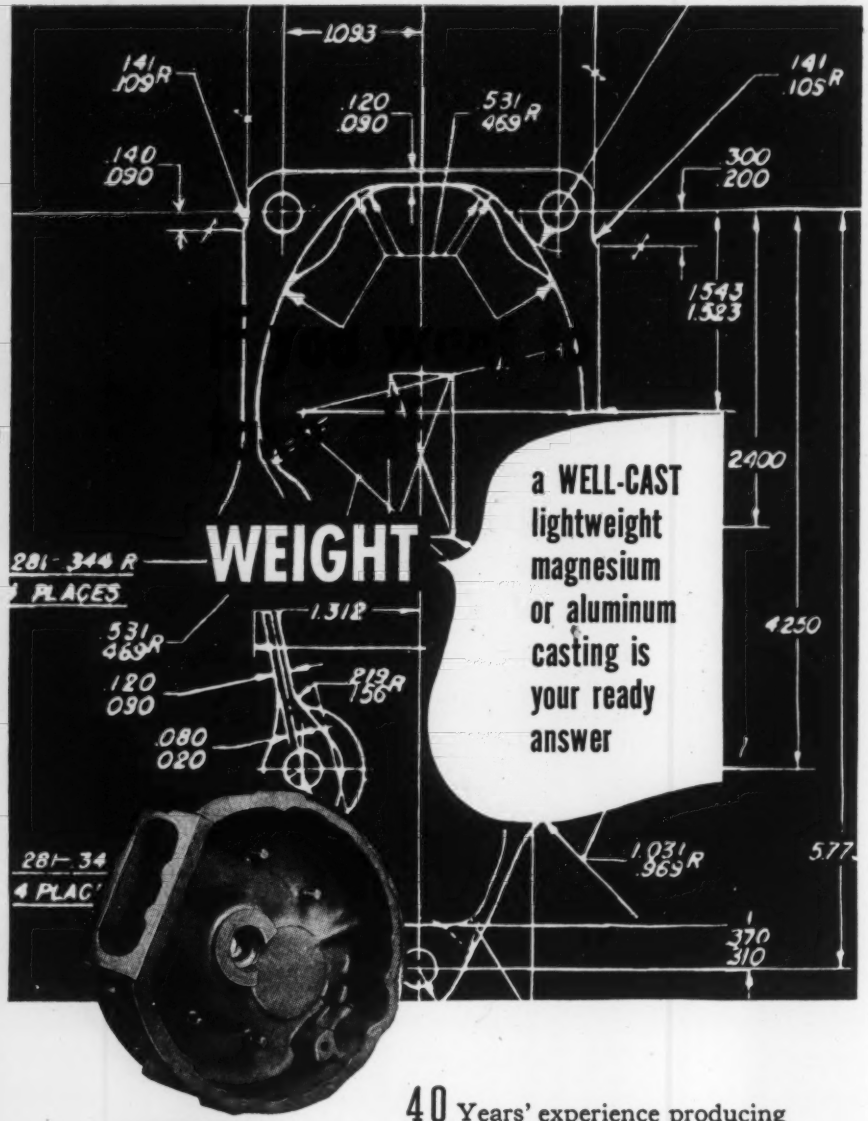

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tors," instead of being asked to *report* on performance actually evinced by employees as they carry out their functions. It is all a matter of opinion, of course, but in building a performance evaluation instrument, we lean toward the use of "action" statements which describe employee behavior as it is observed on the job; for example, statements like "needs to be wound up frequently," "requires detailed instructions before he can be turned loose," "will voluntarily work after hours when a tough problem is under way," "tries to flatter the boss," etc. Such items can be scaled to determine how favorable or unfavorable they are in their meaning; they can be checked for ambiguity in their meaning, and they can then be analyzed for their ability to actually differentiate effective from ineffective engineering personnel. It is our feeling, and there is some evidence to support this, that such scales are accepted by raters as being a little more practical and realistic, and that they are less subject to rater distortion, either consciously or subconsciously.

—JOHN OWEN
Personnel research supervisor
Hamilton Watch Co.

". . . recognize and reward personal attributes"

To The Editor:

I am particularly gratified to have the comments of John Owen, personnel research supervisor, Hamilton Watch Co., on my modest ideas on evaluation of creative engineering.

Mr. Owen questions two areas of my approach to the evaluation of creative engineering: one is the use of the greater number of 34 job factors and the second is the attempt to employ these factors for purposes of merit rating.

In routine repetitive work, the job content is specific, measurable and not influenced by the particular virtues of the individual who happens to occupy the job. In creative engineering, on the other hand, the incumbent makes the job and his personal attributes strongly influence the job content. It was our purpose to recognize and reward those personal attributes that led to the adoption of the more intangible factors which make up the difference between the customary 15 factors and our selected 34 factors. We attempted to isolate and evaluate the additional 19 personal attributes which "spell-out" the creative engineering job and to avoid confusion of these with the ordinary routine elements of job content.

In respect to merit rating of creative engineers, the tie-in betwen job

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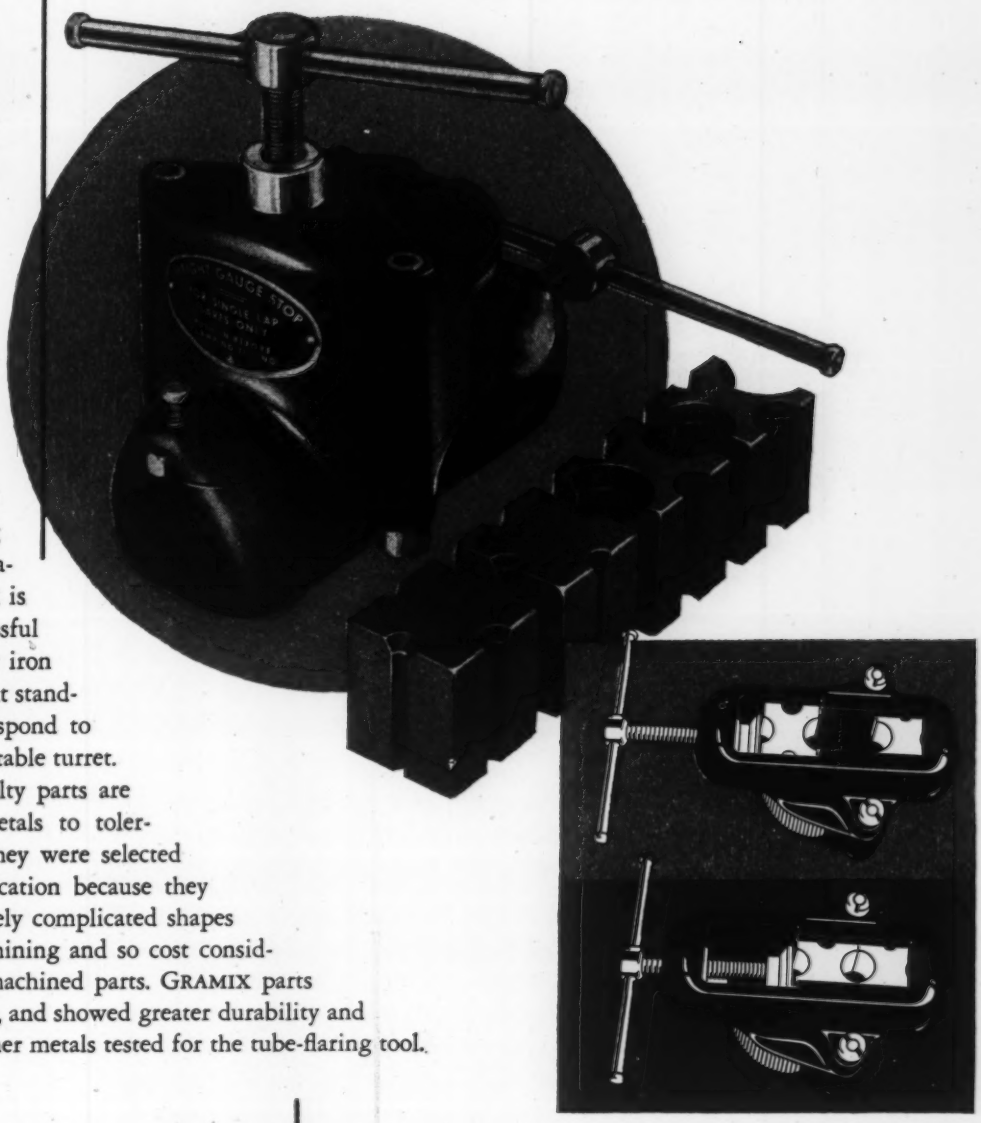

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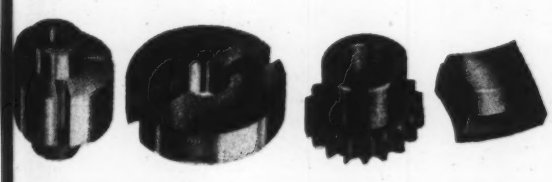

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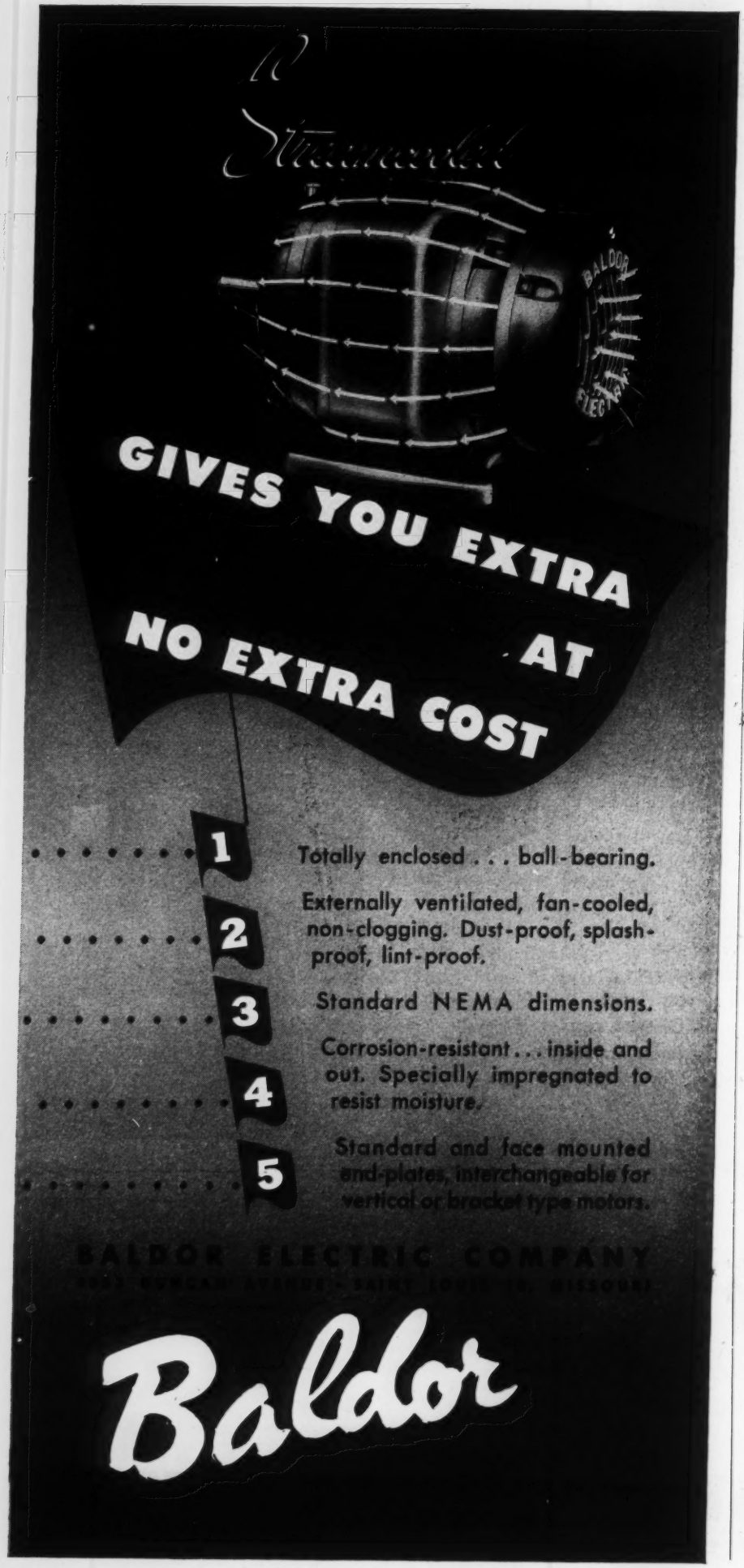


evaluation and rating of individual performance sought three definite indications, namely:

1. Has the individual incumbent failed to fulfill the requirements of the job in terms of the job requirements, and is eligible, therefore, for further training or for demotion?
2. Has the individual incumbent just succeeded in fulfilling the requirements of the job and may, therefore, be continued in the assignment without further recognition?
3. Has the individual incumbent more than fulfilled the requirements of the job and in fact, demonstrated a superior capacity to fulfill the requirements of the next higher job and is eligible for advancement when an opening occurs?

Whatever the process of merit rating, by all means discuss the rating frankly and objectively with the ratee. However, in such, I believe that the review should be closely related to the opportunities for advancement and the qualities which must be improved before advancement can be deserved. In other words, the shortcomings and strong points of the ratee should be discussed in terms of what is required to achieve advancement. The evaluated job content seems to me to be the surest footing upon which to review qualifications.

—RANDOLPH W. CHAFFEE

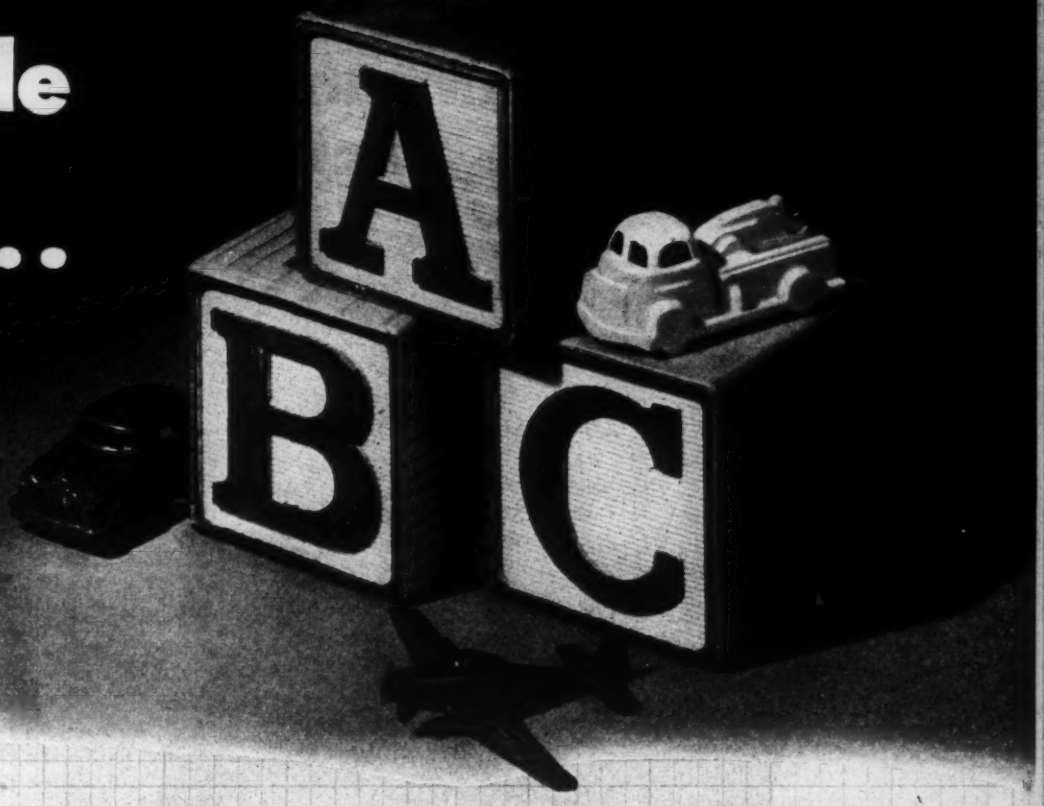
". . . observe the whole as an integrated unit"

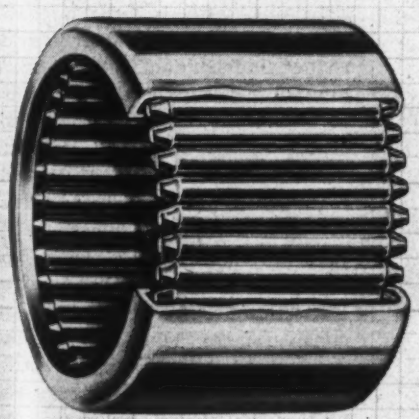
To The Editor:

I would, of course, agree with Mr. Chaffee that, very probably, there are more so-called factors which contribute to effective performance in an engineering position than there are in jobs requiring considerably less creativity and ingenuity. However, merely enumerating a number of factors "believed" to be contained in a given job—and then including them on a rating scale—does not necessarily mean that we will obtain valid and independent evaluations of each of the various attributes recognized. Actually the accumulated evidence indicates that ratings on supposedly specific traits and job factors are not as discrete as we perhaps once thought them to be. For example, Mr. Randolph Driver of The Atlantic Refining Company has reported (*Personnel,* Volume 16, Pages 137-162) a study of an industrial merit rating scale from which he discarded several traits because the intercorrelations were too high. The intercorrelation among the ten remaining traits, which Driver considered to be the most discrete of those comprising the original scale, yielded correlation coefficients ranging from 0.11 to 0.71, with a mean coefficient of 0.46. Such are indicative of appreciable overlap among the various factors considered.

Quite recently, Mr. C. E. Jurgensen of the Minneapolis Gas Company has reported (*Journal of Applied Psychology,* Volume 34, Pages 240-243)

simple as . . .





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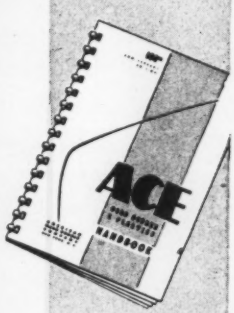

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the findings from a study of an eight-factor graphic rating scale which had been developed in an attempt to reduce the factor intercorrelations. The method employed as a possible control over high factor intercorrelations consisted of selecting only factors that appeared to represent a cluster of subtraits, and then defining these broader factors rather fully. The resultant factors (such as mental ability, work habits, and physical ability) were found to present intercorrelation coefficients ranging from 0.33 to 0.84, with a median coefficient of 0.60. One of Jurgensen's conclusions from his study is that ". . . it would therefore appear unnecessary and unwise in many rating situations to obtain trait ratings."

Probably the next question is this: Why are intercorrelations among job factors so high? Most authorities agree that it probably results from (1) the inability of many raters to differentiate among the more or less abstract factors which are so often considered, and a failure to isolate them in their mental appraisal; and (2) an infectious malady known as the "halo effect." A description of the "halo effect" goes something like this: people tend to have a generalized opinion of a thing or a person—in the case of merit rating, a subordinate—which so permeates their reasoning with regard to that subject that they can't (or at least don't) render independent judgments on a number of supposedly specific factors or traits which might be considered. Stated differently, if I am favorably impressed by the overall performance of a subordinate there is a strong tendency for me to be rather favorably impressed with specific things concerning that individual. For example, if a certain employee is considered to be a good worker *in general,* he is likely to be rated quite high on such specific factors as adaptability, job knowledge, endurance, application and so on, whether such is the case or not.

Because of the foregoing points (and other so-called rating errors not discussed), we prefer a rating procedure that requires the supervisor to report the job performance of his employees in terms of statements describing typical on-the-job behavior. When a sufficiently large number and range of descriptive statements are presented the supervisor is able to report on an adequate sample of a given employee's observed on-the-job performance. If two or more individuals who are familiar with the employee's performance independently render such a report, the chances of a more trustworthy evaluation are increased. It all resolves itself to the

fact that if supervisors *report* on the performance of their employees by indicating which of a number of statements are the most descriptive and the least descriptive of their observed behavior, there is no concern with enumerating a list of specific factors on which the employees are to be *rated*. The selection of descriptive statements for use in a performance report of this type involves a little research in item analysis, but it's well worth the trouble, we believe.

This type of performance report to which I've been referring was described by Dr. E. Donald Sisson in an article entitled "Forced Choice—The New Army Rating" (*Personnel Psychology*, Volume 1, Pages 365-381). The sum of the weights of the discriminating statements which are selected for an employee whose performance is being reported by a forced-choice scale constitutes a performance "score". The scores of the various employees under review are then converted into values conforming to the normal probability curve, and from this it is possible to interpret the performance of any individual employee in relationship to others with whom he is working and who are serving in a similar capacity. Ratings on specific factors and traits which may or may not be involved in job performance are unnecessary in the forced-choice approach to performance evaluation. Moreover, the descriptive statements of observed behavior which are used in the forced-choice report can be checked for ambiguity in their meaning, and by eliminating ambiguous terms and statements, we remove a lot of the basis for spurious impressions.

I don't believe anyone would take exception to Mr. Chaffee's attitude that the results of merit ratings should always be discussed with ratees, and that it should be done in a constructive and realistic manner. After all, this is one of the two or three objectives intended to be fulfilled by a merit rating program, and from the standpoint of employee morale it is probably one of the most important implements we have.

Very probably, the differences in opinion between Mr. Chaffee and myself stem from the fact that one of us looks at the rating question from an empirical point of view and the other leans a little heavier upon the findings from research which has been conducted with rating instruments.

—JOHN OWEN

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To The Editor:

Candidly, I must seek shelter be-

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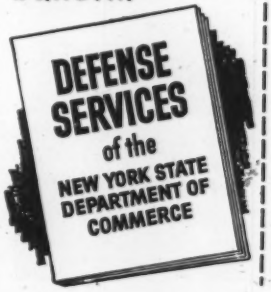

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hind Mr. Owen's concluding paragraph.

The success of any program for job evaluation or merit rating rests firmly upon the understanding, approval and support of the incumbents and ratees. It seems to me that the fruits of academic research are applicable only to the extent that they are readily understandable to the lay mind, and that the empiric approach must take over beyond that point. In the program described in MACHINE DESIGN, the empiric approach dominated and won acceptance by the organization.

We were not concerned primarily with any arbitrary restriction upon the number or quality of rating factors, nor with the quantitative values placed upon individual ratings. Rather, we sought to rate the incumbents in terms of his (or her) fulfillment of the acknowledged job requirements, and to use these job requirements to direct the raters' response along the most objective lines.

With complete respect for Mr. Owen's point-of-view, I submit that organization morale gains the greatest practical benefit from the application of basic principles which merit and win the understanding, approval and active support of the organization members, however empirical those principles may be.

—RANDOLPH W. CHAFFEE

Design Abstracts

(*Continued from Page* 156)

and availability, are usually adequate for the solution of engineering design problems.

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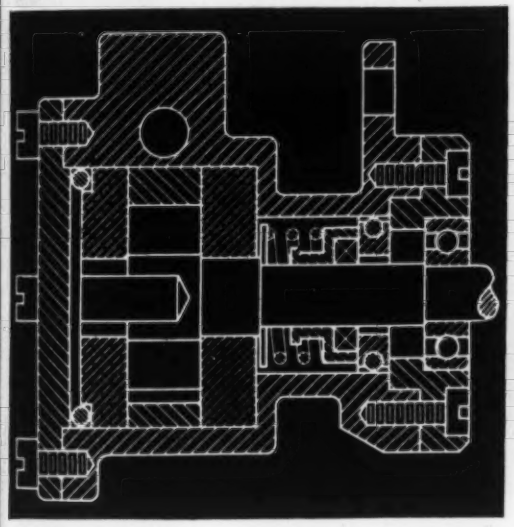

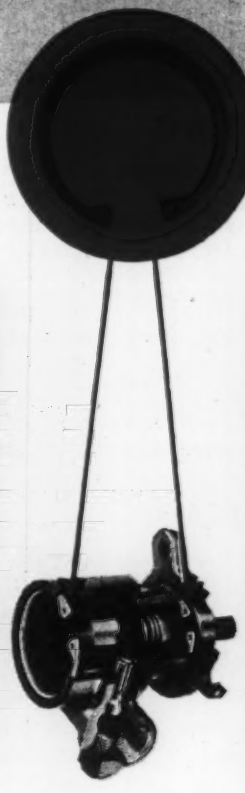

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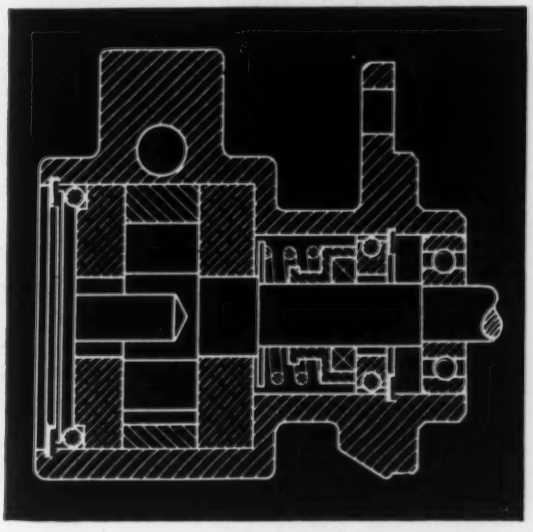

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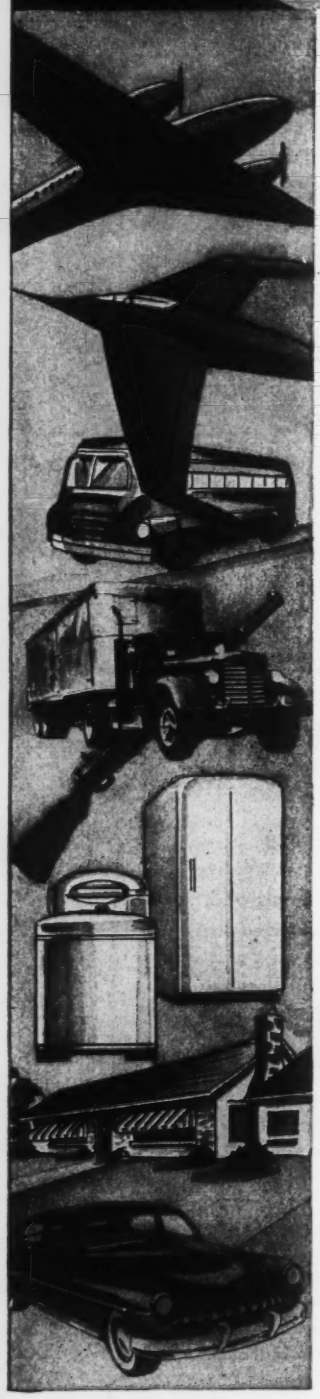

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From Paper No. 51—F-2, "Characteristics of Dished-Plate (Belleville) Springs as Measured in Portable Recording Tensiometers," presented at the ASME Fall Meeting in Minneapolis, Minn., September 25-28, 1951. Complete copies may be obtained from ASME, 29 W. 39th St., New York 18; $0.25 each to members, $0.50 to nonmembers.

Engineering of Farm Machinery

By C. E. Frudden

Allis-Chalmers Manufacturing Co.
Milwaukee, Wis.

THE change on American farms from horses and mules to tractors and tractor-operated implements has been the biggest single thing that has happened to agriculture in modern times. This change has released for the production of human food some 50,000,000 acres of cropland that were previously required to feed the work animals on farms.

Man-power requirements on well-mechanized farms have become less and less. One man can now grow and harvest a bushel of wheat in five minutes; a bushel of corn in four minutes. On the basis of present market prices, direct labor costs are on the order of 5 per cent of the market price of the crop, 95 per cent representing the cost of land and machinery, operating expenses, seed, fertilizer, and other overhead. Other factors, such as better seeds, more fertilizer, etc., have had their share in reducing labor costs per bushel and increasing returns per acre, but modern power-operated farm machinery has had a big influence.

Farm machinery, so far as this paper is concerned, consists of the farm tractor and an almost endless array of implements which are associated with the tractor, either connected to the drawbar and pulled be-

(*Continued on Page 218*)

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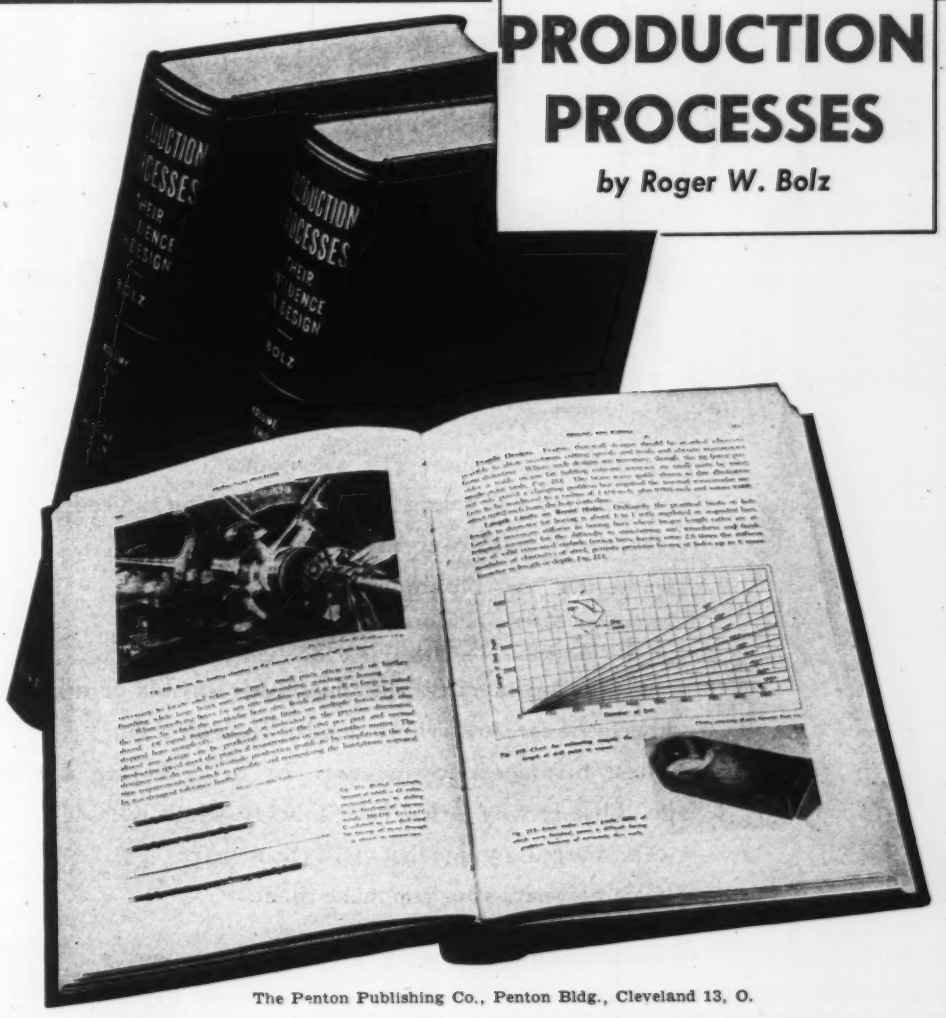
by Roger W. Bolz



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(*Continued from Page* 214)

hind the tractor or mounted on the tractor frame to form an integral or self-powered machine.

The early tractors were relatively simple machines. They were fitted with a drawbar to which were attached such implements as plows and harrows, and with a belt pulley by which power could be furnished to operate threshing machines. Mainly tractors were horse replacements for pulling horse-drawn implements.

Now the trend in tractors and implements is toward a basic tractor, engineered to conform to the requirements of growing an almost endless variety of crops, particularly those grown in rows like cotton, soy beans, and corn. These require cultivation after the crop has grown to a considerable height and, therefore, high clearance under axles as well as means for adjustably spacing the wheels to fit the crop rows. Such a basic tractor then becomes a carrier, as well as a portable power plant, for many implements—plows suspended from the rear of the tractor, disk harrows similarly suspended, planters either ahead of or behind the rear wheels, cultivators both ahead of and behind tractor rear wheels, corn pickers, and other combinations almost to infinity. Other implements which receive their power from the tractor, such as combines, forage harvesters, hay balers, mowers, and rakes, are carried on their own wheels and are pulled behind the tractor.

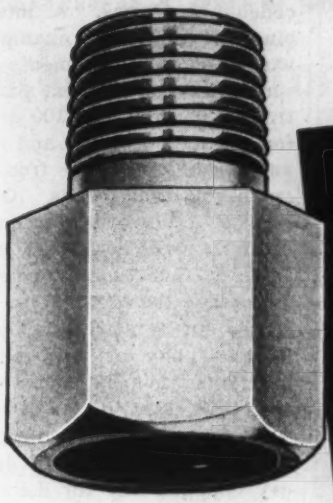
As an economy measure, much capital investment is being saved by mounting implements on the tractor rather than carrying them on their own wheels and pulling them from the tractor drawbar. Handiness of operation also goes with tractor-mounted implements.

Low Use Factor Affects Design

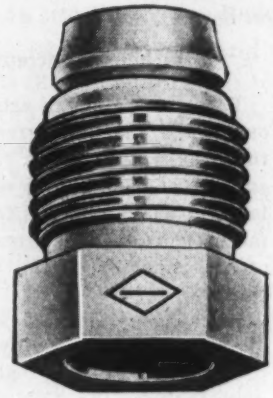
Farm machinery, both in its design and economic aspect, differs from most machines in industry in that it has a very low "use" factor. That is, on the whole, few farm implements are used more than ten or twelve days during any one season. Timeliness is the essence of good farming, and a tractor-operated farm machine must have large capacity in order to get a lot of work done while conditions of crops, soil, and weather are favorable. As a result of this situation, while tractors may be operated as much as 100 full days per year, very few attached implements are used for as much as two weeks per season. Not much can be done about this by the implement designer.

Designing farm machines with maximum versatility of use rather than for

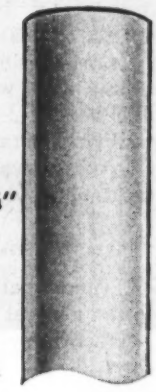
. . . Saves man hours through faster assembly



IMPERIAL Hi-Duty FITTINGS

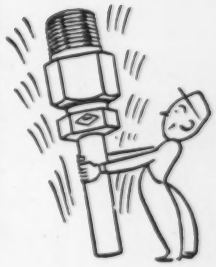


FOR O.D. TUBING SIZES FROM ⅛" TO ¾"

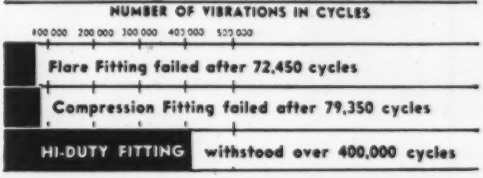


STANDS UP BETTER UNDER VIBRATION

Because they keep tubing deformation at the minimum, Imperial Hi-Duty Fittings withstand over 5 times as much vibration as joints made with compression or flared brass fittings. (See chart below.) Sleeve is a part of nut, thus assuring perfect alignment with tubing in assembly.

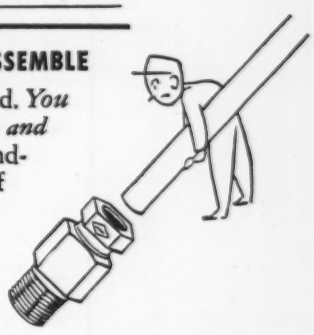


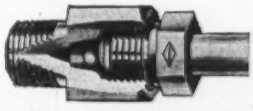
Comparative Vibration Test Results


NUMBER OF VIBRATIONS IN CYCLES
100,000 200,000 300,000 400,000 500,000
Flare Fitting failed after 72,450 cycles
Compression Fitting failed after 79,350 cycles
HI-DUTY FITTING
withstood over 400,000 cycles

EASIER AND QUICKER TO ASSEMBLE

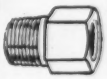
Fitting comes with nut assembled. *You simply push tube into fitting and tighten the nut* to make dependable, pressure-tight, leak-proof joints. No loose sleeve to contend with . . . no tube flaring required.

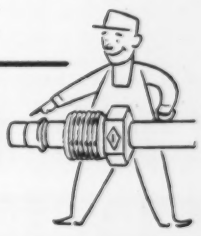




REPEATED TIGHT RECONNECTION

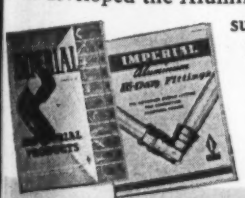
Sleeve shears off at groove when nut is tightened and *becomes attached to tubing*, creating a union joint which will make repeated reconnections.





Furnished in Brass or Aluminum — Ask for Catalog 350 which describes these outstanding brass tube couplings which have won such widespread preference in the field.

With the growing use of aluminum tubing, Imperial has developed the Aluminum Hi-Duty Fittings. They offer such advantages as light weight, high strength and good corrosion resistance. Ask for Bulletin 365.

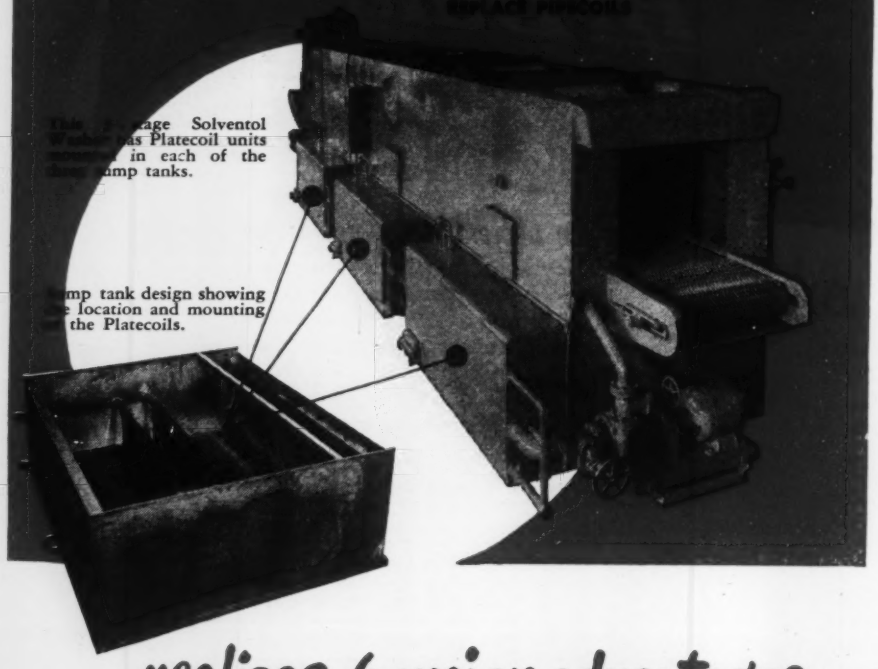


Specialists in
TUBE FITTINGS *OVER 2000 STOCK ITEMS.*
Catalog 350 shows a wide range of sizes, types and styles. Write for copy.
"Look for the Diamond ◇ on every fitting you buy"

IMPERIAL

THE IMPERIAL BRASS MANUFACTURING COMPANY • 513 South Racine Avenue, Chicago 7, Illinois

now! SOLVENTOL CHEMICAL IS SAVING MONEY with PLATECOILS



...age Solvent
...as Platecoil units
... in each of the
...mp tanks.

...mp tank design showing
... location and mounting
... the Platecoils.

... realizes 6 major advantages

Solventol Chemical Products, Inc., Detroit, Michigan has joined the growing list of manufactures who are saving money by using Platecoils in their products. Use of Platecoils as the heating medium in their 3-stage washer has resulted in 6 major advantages:

1. *Simplified installation.*
2. *Sharply reduced installation costs.*
3. *A higher rate of heat transfer.*
4. *Low first cost.*
5. *Solution flow controlled without baffles.*
6. *Increased sales advantages due to easier maintenance.*

The Platecoils are installed in each of the three sump tanks as shown in the inset picture. The pre-fabricated Platecoil units are installed in but a fraction of the time required for bending and installing pipe coils. That's why most manufacturers find it costs less to buy and install Platecoils than to fabricate pipe coils in their own plant.

In addition, the Platecoils are about 50% more efficient than pipe coils. As a smaller size Platecoil can be used, considerable savings in steel and more compact machine designs are possible.

If you're looking for ways to conserve steel and save money, get the facts on Platecoil today. Write for bulletin P71.

a single purpose may not be ideal engineering, but it is generally excellent economics. A modern combine harvester, for example, with a wide range of adjustments and an assortment of component parts, has no trouble in threshing 100 or more different kinds of grass and grain seeds varying in kernel size from tiny clover to big lima beans. On many a farm such versatility means that one combine will be called into action three or four times during a season.

Forage harvesters are also designed for versatility. They cut the standing hay or corn and chop it into short lengths and are designed to handle crops in four different ways: (1) green grass for grass silage, (2) corn for corn silage, (3) dry or semi-dry chopped hay for delivery to hay mow, and (4) chopped straw for bedding.

Attachments Increase Use

These variations in attachments for one basic machine greatly improve the otherwise low use factor of this equipment. They also make possible larger production runs for the manufacturer as well as great usefulness of the machine in the hands of the farmer.

Engineering and design of machines are always influenced by the possible production volume attainable in manufacture. In this respect, farm machinery may be said to have reached the mass production stage which makes possible the many economies associated with production in large numbers.

Engineering of farm machinery can be divided into two broad groupings: the functional and the mechanical.

Inventiveness Important

Under functional design, we might include the general application of machine elements to the job of mechanizing agriculture. Here, the inventors —very often the farmers themselves— have a big play, scheming up ways and means of doing mechanically what is hard work doing by hand or developing ways and means to improve upon existing machines. Our hats are off to the farmers and farm boys who have displayed unusual ingenuity in pointing out the hard jobs and offering suggestions for lightening the work by mechanical means. It seems that being very close to the farm, or having a good farm background, is the first prerequisite for successful inventive ability in this field. One thing is certain—these farmer-inventors have been prolific, and the patent office records attest to their numerous activities.

The mechanical design of farm machinery is more and more closely fol-

Lubrication's sure and easy on Rocker Arm Straightener

Multival Centralized System is standard equipment

USERS of this Impco rocker arm straightening machine are pleased with its smooth, trouble-free operation. Lubrication is no problem because every machine is equipped by the manufacturer with a Multival Centralized Lubricating System.

Multival is simple, streamlined and efficient—low in cost, easy to install and easy to operate. There is no fuss, no muss, no waste, no burned out bearings, no shutting down the machine for lubrication.

A man with a grease gun makes one connection at the Multival Block. With a single stroke, he fills all the measuring valves, which at the same time deliver an exactly measured quantity of oil or grease to each bearing served by the system. The system can be operated as often or as seldom as necessary, and the amount of lubricant delivered is adjustable to each individual bearing need, so that no bearing gets too much or too little.

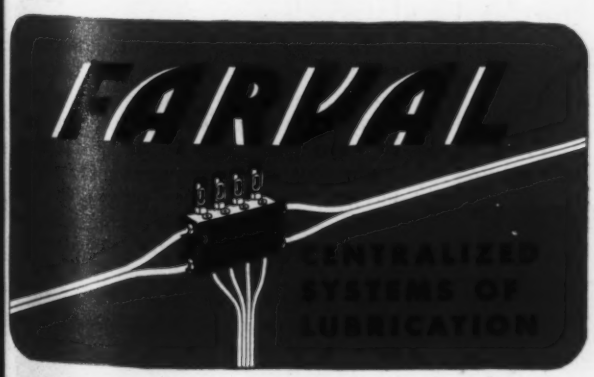
Multival is a Farval-engineered product, incorporating the unique Farval valve and piston design. The Farval valve is simple, sure and foolproof, without springs, ball-checks or pinhole ports to cause trouble. Wide valve ports and full hydraulic operation insure unfailing delivery of grease or oil to each bearing—as much as you want, exactly measured—as often as desired.

Write for Multival Bulletin 15 or Farval Bulletin 25. The Farval Corporation, 3265 East 80th Street, Cleveland 4, Ohio.

Affiliate of The Cleveland Worm & Gear Company, Industrial Worm Gearing. In Canada: Peacock Brothers Limited.

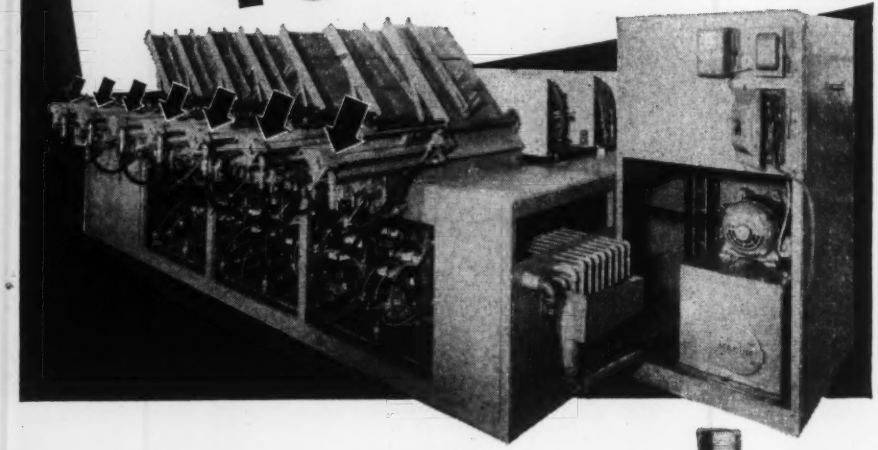
● *Greasing this rocker arm straightener takes only a few minutes, because it is Multival-equipped. For larger machines for straightening crankshafts, this machinery builder, Industrial Metal Products Corporation of Lansing, Mich., has standardized on Farval Centralized Systems of Lubrication.*

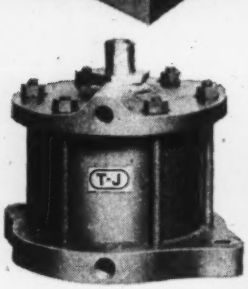
FARVAL—*Studies in Centralized Lubrication*
No. 125

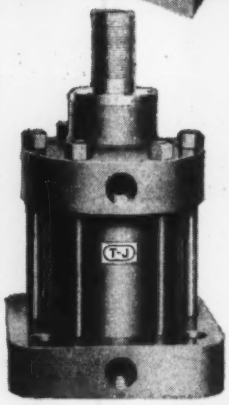


Job File No. 3259

Feeds Automatically WITH T-J CYLINDERS





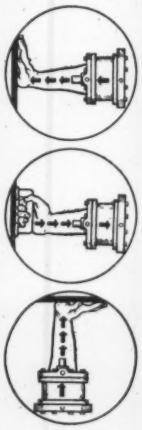


T-J Hydraulic Cylinders furnish efficient, automatic "push power" for feeding devices in this new Ajax-Northrup induction forge heating equipment.

This unit—manufactured by Ajax Electrothermic Corp., Trenton, N. J.—automatically heats steel forging stock in sizes ranging from 1 to 4 inches (rounds or squares) at 2250°F. at rate of 7500 to 8500 lbs. per hour. Has space for 8 heating stations . . . each with *hydraulically operated billet feeding devices employing T-J Cylinders.* These cylinders also eject heated bars automatically. Induction heating with this equipment results in uniformity of successive billets fed to the forge—thus controlling quality of finished forgings and reducing rejects.

Do you have a tough job in power movement—pushing, pulling or lifting? Let T-J help you *simplify machines, save labor* and *cut costs* by using T-J Air or Hydraulic Cylinders! Many standard sizes and styles . . . cushioned or non-cushioned . . . 100 lb. or 50,000 lb. Precision-built, long life. Write for more information. The Tomkins-Johnson Co., Jackson, Mich.

FOR POWER MOVEMENT IN ANY DIRECTION



100 LBS. or 50,000 LBS.

35 YEARS EXPERIENCE

TOMKINS-JOHNSON

RIVITORS . . AIR AND HYDRAULIC CYLINDERS . . CUTTERS . . CLINCHORS

T-J

lowing the automotive trend. This is natural, since the high-speed, automotive type of internal combustion engine is the source of power, and the transmission of this power through clutches, gearing, shafts, and universal joints to axles and rubber-tired wheels, in general, follows automotive practices.

The development of the mechanical design for a farm machine, which will be manufactured in large numbers and continue in production for several years, generally follows a prearranged program. First is the application of the best available engineering information as to stresses and choice of materials for the various elements. Then comes the testing laboratory where the machine as a whole, as well as its component parts, passes through accelerated or overload tests to pick out the weak spots so far as these tests will find them. Following this, for many of the machines, a proving ground provides additional accelerated testing for weak spots and wear, while concurrently another lot of machines is placed with representative farmers for observation under regular working conditions. Because of short testing seasons, the development program often extends over three or four years before production plans can be finalized.

To speed up the proving-ground test programs, many companies maintain testing facilities at Phoenix or San Antonio so that year 'round testing operations can be carried on with a minimum of interruption.

Dust Causes Failures

Failures in farm machinery parts are almost always related either to wear or to fatigue life. Wear in practically all cases results from the action of abrasive dust, and farm machinery must operate much of the time in a continuous cloud of dust. Out of years of experience, dust seals and air cleaners have been developed to a high degree of efficiency, but small quantities of dust that still get through can do damage. Dust is without question, farm machinery's greatest enemy. As to tractor component parts, engine cylinders experience the most rapid wear on account of dust.

To meet these difficult conditions, tractor engines are, as a rule, built with renewable cylinder liners, or their equivalent, so that replacement of worn parts can be made at minimum cost when required. Corrosive effects, which seem to plague the automobile engineer, are considered to be a secondary problem in tractor engine operation.

An engineering discussion of farm machinery, and of rubber-tired tractors in particular, would be incom-

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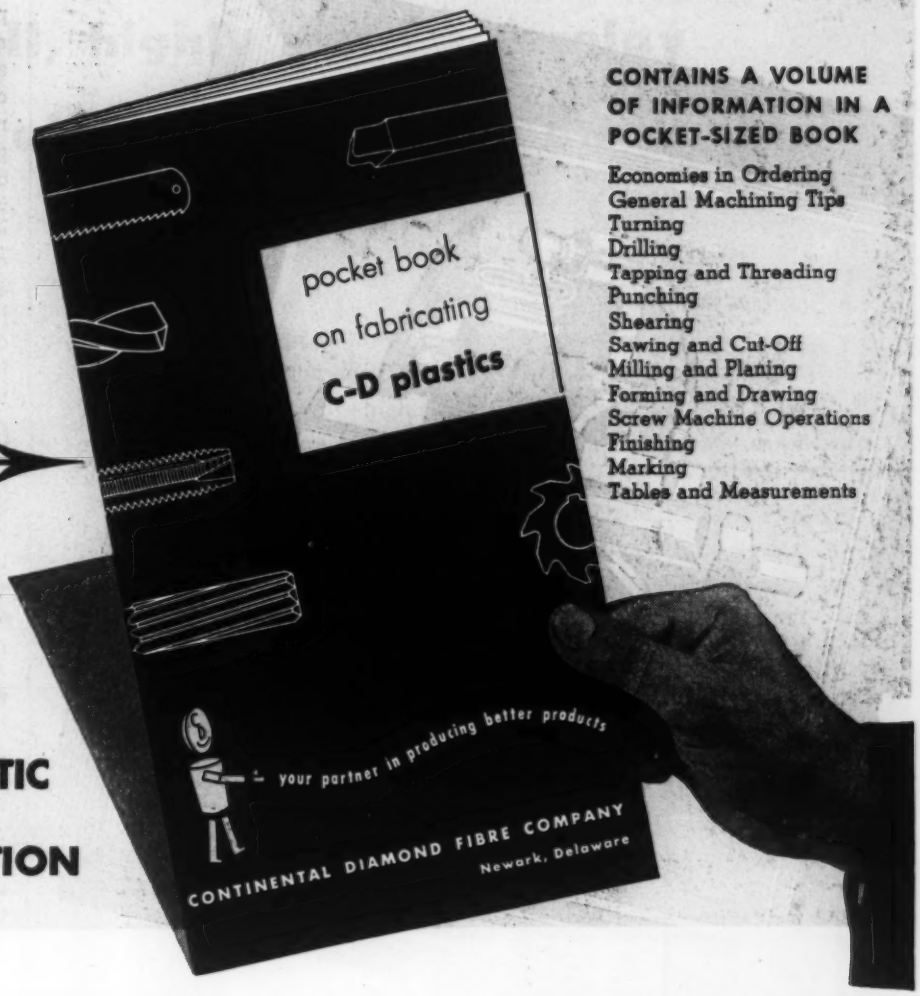
- **REDUCE COSTS**
- **CONSERVE PLASTIC**
- **SPEED FABRICATION**



CONTAINS A VOLUME OF INFORMATION IN A POCKET-SIZED BOOK

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This NEW "Pocket Book on Fabricating C-D Plastics" places at your fingertips a wealth of practical, easy-to-use information that can help you conserve plastics . . . speed assembly . . . lower fabrication costs . . . get more production from every man working with plastics.

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Established 1895 . . Manufacturers of Laminated Plastics since 1911 — NEWARK 23 DELAWARE

PORTRAIT...

OF *Advanced* FAWICK CLUTCH ENGINEERING

Advances in engineering and in operating efficiency are typical of Fawick Airflex design developments to provide industry with better, simpler pneumatic power transmission.

Written into the operating stories of these superior clutch and brake units you will find many advantages that will improve the production efficiency of your machines. For instance, the ventilating adapter in the Fawick CB Clutch shown above creates forced-air circulation through the entire unit for cooler clutch operation under all working conditions.

SPACE SAVING, SELF-ADJUSTMENT, CUSHIONED POSITIVE ACTION, and LOW MAINTENANCE are additional "built-in" features of FAWICK CLUTCHES AND BRAKES that are continuously benefiting thousands of machine operators.

FAWICK AIRFLEX COMPANY, INC.
9919 CLINTON ROAD • CLEVELAND 11, OHIO

For further information on Fawick Industrial Clutch and Brake Units, write to the Main Office, Cleveland, Ohio, for Bulletin ML-22.

FAWICK *Airflex*
INDUSTRIAL CLUTCHES AND BRAKES

plete without reference to the subject of traction or tractive effort or drawbar pull, the nomenclature depending upon the party talking. A railway locomotive, on dry track, can exert a drawbar pull of about 20 per cent of its weight on drive wheels. A rubber-tired tractor under favorable ground conditions can do 65 per cent, but as the footing becomes less favorable, in sand for instance or in wet fields, the maximum drawbar pull may drop to 20 or 25 per cent. For any given ground condition, drawbar pull is entirely a function of weight on drive wheels. A normal design of tractor provides insufficient weight to fully utilize the power of the engine in the lower speeds of travel; hence, it is necessary, in order to get maximum performance, to deliberately add weight to the tractor in as economical a form as possible. Cast iron weights, attached to drive wheels, may add 20 to 25 per cent to the tractor's weight, and the same percentage to available drawbar pull. Another method commonly used is to fill the tire about 80 per cent full of liquid, generally a solution of calcium chloride in water which is a good antifreeze when used in rubber containers. This will add another 20 or 25 per cent to weight on the drive wheels and has the advantage of doing so without imposing this load on the tractor tires or on the tractor axles.

Hydraulic System Adds Traction

A third method of boosting traction, used in connection with certain tractor-mounted implements, is to establish a low draft line tending to induce a working depth of the implement lower than is desired and then applying a lifting force from the tractor to maintain the working depth desired. The means for accomplishing this action consists of a spring - cushioned drawbar whose movement, beyond a predetermined amount, controls a hydraulic system which, in turn, tends to partially lift the implement and thereby adds weight to the drive wheels. The limit of such weight transfer is, of course, reached when the front wheels of the tractor are lifted from the ground, but this does provide a very substantial increase in drawbar pull at no cost for added material.

In practice, all three of these methods for "boosting" traction in various combinations are being used. No less important than the engineering phases of tractors, and in many ways much more intriguing and involving much greater ingenuity, is the engineering of tractor implements. There are innumerable implements

THE *New* CLARE TYPE "N" RELAY...

a small, highly sensitive relay designed for efficient operation on low power*

CLARE Type "N" RELAY

CLARE Type "N" Relays are designed for operation on extremely low power. A close-coupled magnetic circuit, generous use of magnetic iron, and unusually efficient coil design give high sensitivity while retaining high contact pressure (minimum 30 grams) and adequate contact gap (minimum 0.015").

Other important advantages include small size, light weight, and especial adaptability to hermetic sealing. Type "N" Relays having not more than 14 terminals for coil and contact springs can be hermetically sealed in enclosures of extremely small size.

For more detailed information on Clare Type "N" Relays you are invited to write for Bulletin No. 109. Clare sales engineers are located in principal cities. Call them or write C. P. Clare & Co., 4719 West Sunnyside Avenue, Chicago 30, Illinois. In Canada: Canadian Line Materials, Ltd., Toronto 13. Cable Address: CLARELAY.

SPECIFICATIONS of CLARE Type "N" RELAY

COIL

OPERATING VOLTAGE

ARMATURE

CONTACT ASSEMBLY

CONTACTS

TERMINALS

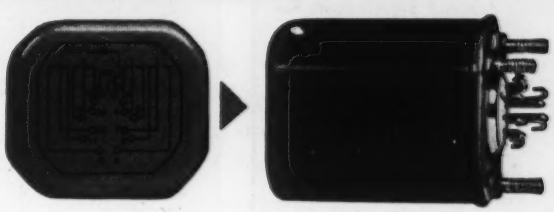
DIMENSIONS

NET WEIGHT

MOUNTING

*With a 10,000-ohm coil, 1 Form C contact (spdt), and a standard adjustment, this relay will operate on less than 50 milliwatts. With a 450-ohm coil and four Form C contacts (4pdt), it will operate on 7/10 watt, even under conditions of vibration and high ambient temperature.

Clare Type "SN" Hermetically Sealed Relay



Shown above is one of the hermetically sealed steel enclosures in which the Type "N" Relay can be sealed. Dimensions are: Length: 1-7/16"; Height: 2-1/16"; Width: 1⅝". Net weight of relay having 12 contact springs, six in each pileup, is 5 oz. (approx.). Note connection diagram clearly and permanently imprinted on base of enclosure by silk screen process.

Write for CLARE Bulletin No. 109

CLARE RELAYS

Invest in the Industrial Field

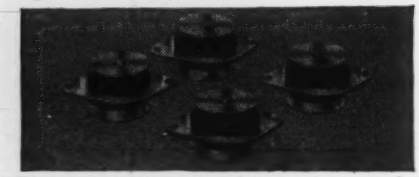
SHOCK and VIBRATION NEWS

BARRYMOUNTS FOR ASSURED CONTROL OF SHOCK AND VIBRATION

SMALL PLATE-TYPE BARRYMOUNTS

for Mounting Light Industrial Equipment

New Series 6300 Barrymounts are designed to fill the need for plate-type vibration isolators requiring little mounting space and carrying light to moderate loads.



Unit mountings in this series can be furnished with load ratings as low as one pound and up to 11 pounds. The free height of the top of the unit mounting, above the central mounting plate, is approximately 23/64 inch. The symmetrical design permits loads to be applied either axially or radially, or with components in both directions.

Designed primarily as vibration isolators, the Series 6300 units have a transmissibility of about 6 at resonance, which occurs at approximately 15 cycles per second under rated load. Vibration isolation at 30 cycles or above is extremely efficient. The stability of the mounting is excellent, and transient shock isolation is satisfactory for the intended service.

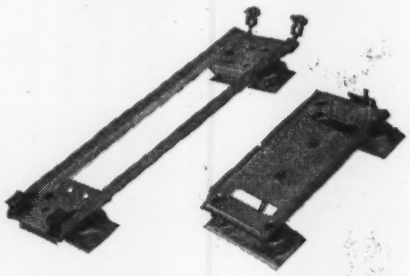
These new Barrymounts are available in two mounting styles: Series 6300, with two holes on 1-13/32 inch centers, and Series 6780, with four holes at the corners of a one-inch square. Detailed ratings, performance data, and dimensions are given on Data Sheet 608. Write for your free copy today!

FREE CATALOGS

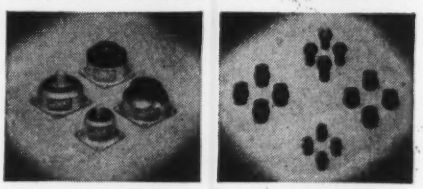
- 502 – Air-damped Barrymounts for aircraft service; also mounting bases and instrument mountings.
- 509 — ALL-METL Barrymounts and mounting bases for unusual airborne applications.
- 504 — Shock mounts and vibration isolators for marine, mobile, and industrial uses.
- 607 — How to cut maintenance costs by using Barrymounts with punch presses.
- 605-606 — Miniaturized air-damped Barrymounts for use with airborne equipment.

STANDARD MOUNTINGS ISOLATE VIBRATION

Available for Aircraft, Marine, Mobile, Instrument, and Industrial uses.

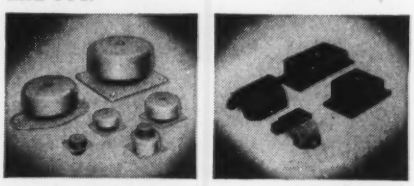


Standard bases built to meet government specifications can be furnished by Barry; special bases can be supplied in sizes and load ratings to fit customers' exact requirements, including miniaturized bases. See catalog 502 and data sheets 605 and 606.



Aircraft vibration isolators designed to meet Army, Navy, and CAA requirements are available in ¼-pound to 45-pound unit ratings; also miniature mounts to 0.1 lb. See catalogs 502 and 509 and bulletins 605-6.

Instrument mountings are furnished for electronic components, tiny, fractional-HP motors, record changers, dictating machines, and other light-weight apparatus. See catalogs 502 and 504.



Shock mountings for mobile, railroad, and shipboard service also give vibration isolation at frequencies above 2000 c.p.m.; useful for general sound isolation. See catalog 504.

Industrial mountings isolate vibration from fans, motor-generator sets, transformers, punch presses, and other heavy industrial equipment. Bulletin 607 tells how to cut maintenance costs with Barrymounts.

THE **BARRY** CORP.

722 PLEASANT ST., WATERTOWN 72, MASSACHUSETTS

SALES REPRESENTATIVES IN

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required to serve the many types of farming, ranging from rather simple plows to very complex cotton pickers. They have one thing in common—a very close relationship to the tractor—and attachment of any implement to its tractor is generally a matter of one man and less than five minutes.

Our company, during the past two or three years, has modernized two of its tractor models in which have been incorporated some advanced thinking regarding design. These items have proven to be of considerable interest, and it might be appropriate to mention them here.

Transmission gears have spirally cut teeth and are constantly in mesh, speed changes being made by sliding jaw clutches. The spiral gears almost completely eliminate gear noises.

Hydraulic power including the Traction Booster, is used to lift implements. The Traction Booster maintains a predetermined draft for any attached implement and when this draft is exceeded, the hydraulic system tends to lift the implement and thereby increase the load on drive wheel. The results are reduced wheel slippage and accurate depth control, both automatically obtained.

Two clutches are used, one a master clutch at the engine flywheel which, when disengaged, stops all motion beyond the engine. This clutch is used when shifting gears and for engaging and disengaging the power take-off drive. It can be used in an emergency to stop all power transmission quickly. The second clutch engages the transmission gears for controlling the forward and reverse movement of the tractor without interfering with the transmission of power to the power take-off shaft and the machinery operated by it. The second clutch is much appreciated during operation of combines, forage harvesters, and hay balers.

Tread spacing of rear wheels with engine power is accomplished through the use of spiral rails or tracks welded to the inner diameter of the rear wheel rims. No lifting is involved and wheel treads can be set at any desired spacing in a matter of two or three minutes. This feature is handy when it becomes necessary to change from a narrow spacing used for plowing to a wide spacing for cultivating or any of the other many tread spans required to conform to the plants being grown.

From a paper entitled "Engineering and Design of Farm Machinery," presented at the ASME Fall Meeting in Minneapolis, Minn., September 25-28, 1951. Complete copies may be ob-

MUELLER BRASS CO.

600 series a better bearing bronze containing no hard-to-get tin

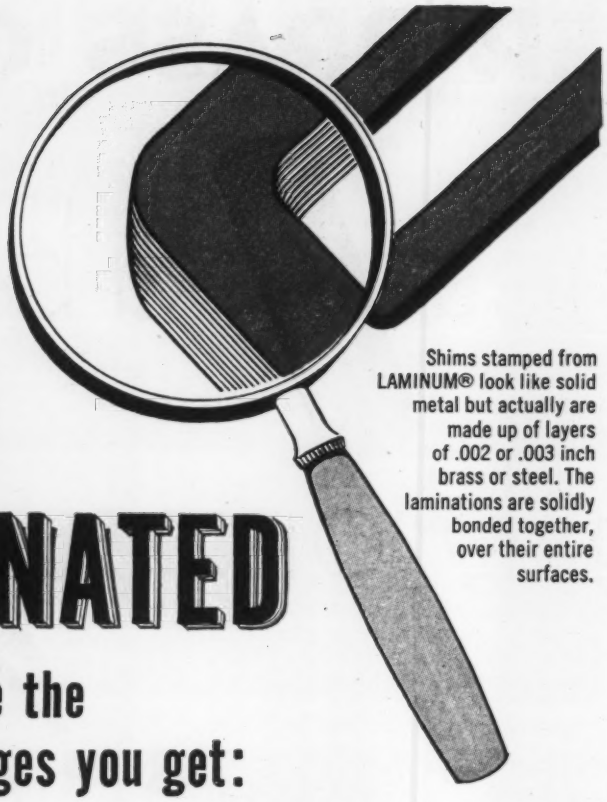
Four typical parts forged from Mueller Brass Co. "600" series Bearing Bronze.

If you use gears, connecting rods or other parts of bearing metal in your products, it will pay you to investigate Mueller Brass Co. "600" series, a forgeable bronze that *contains no critical tin.* This bearing metal outperforms phosphor bronze and other bearing metals and will save you money in your applications. "600" series bearing metal can be forged into relatively complicated shapes and produces a forging of close-grained homogeneous structure impossible to get in a casting. The forged shape is closer to finished size than a casting and requires less machining. "600" series alloys have a low coefficient of friction, a tensile strength 2½ times greater than cast phosphor bronzes and a high resistance to corrosion. "600" has a 25 year record of outstanding performance on some of the toughest bearing applications. There is a "600" series alloy with the properties to fit your bearing metal needs . . . write today for further facts.

MUELLER BRASS CO.

PORT HURON 15, MICHIGAN

64



Shims stamped from LAMINUM® look like solid metal but actually are made up of layers of .002 or .003 inch brass or steel. The laminations are solidly bonded together, over their entire surfaces.

when a shim is

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You machine only to easy tolerances. The laminated shim is *adjustable*—you simply peel laminations of .002 inch brass or steel with a penknife—to get exactly the spacing you need. You cut costs without sacrificing quality.

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Shims come to you in one "pack" for each application. They are precision-stamped to your exact specifications. No counting, no stacking, no miking. Gauge is always known. No dirt or grit can lodge between layers.

SPEEDED PRODUCTION:

Final fitting can be done right at the job. You don't have to take parts back and forth for further machining, grinding or filing. No special skill required. The laminations adjust spacing quickly, easily.

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Throughout the life of the machines you produce, the simple removal of a shim lamination provides a unique adjustment for the take-up of wear. Original clearances can always be restored.

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tained from ASME, 29 W. 39th St., New York 18; $0.25 each to members, $0.50 to nonmembers.

Selecting Researchers

By Dr. H. A. Leedy

Director
Armour Research Foundation
Illinois Institute of Technology
Chicago, Ill.

WHAT makes a good research man?

If we had an easy answer to that question, there would be fewer wasted talents and fewer gray hairs for research administrators. There are some general principles, however, that have proved helpful.

First, we can look at the record: academic accomplishments, scientific writing, patents, and performance in previous positions. Will this man's experience and training fit in with future plans?

Second, we must judge a man's caliber. Is his grasp of scientific fundamentals such that he can direct his efforts to useful end? Is he a self-starter, or will he need constant supervision and urging? In short, is he big enough to see the woods for the trees?

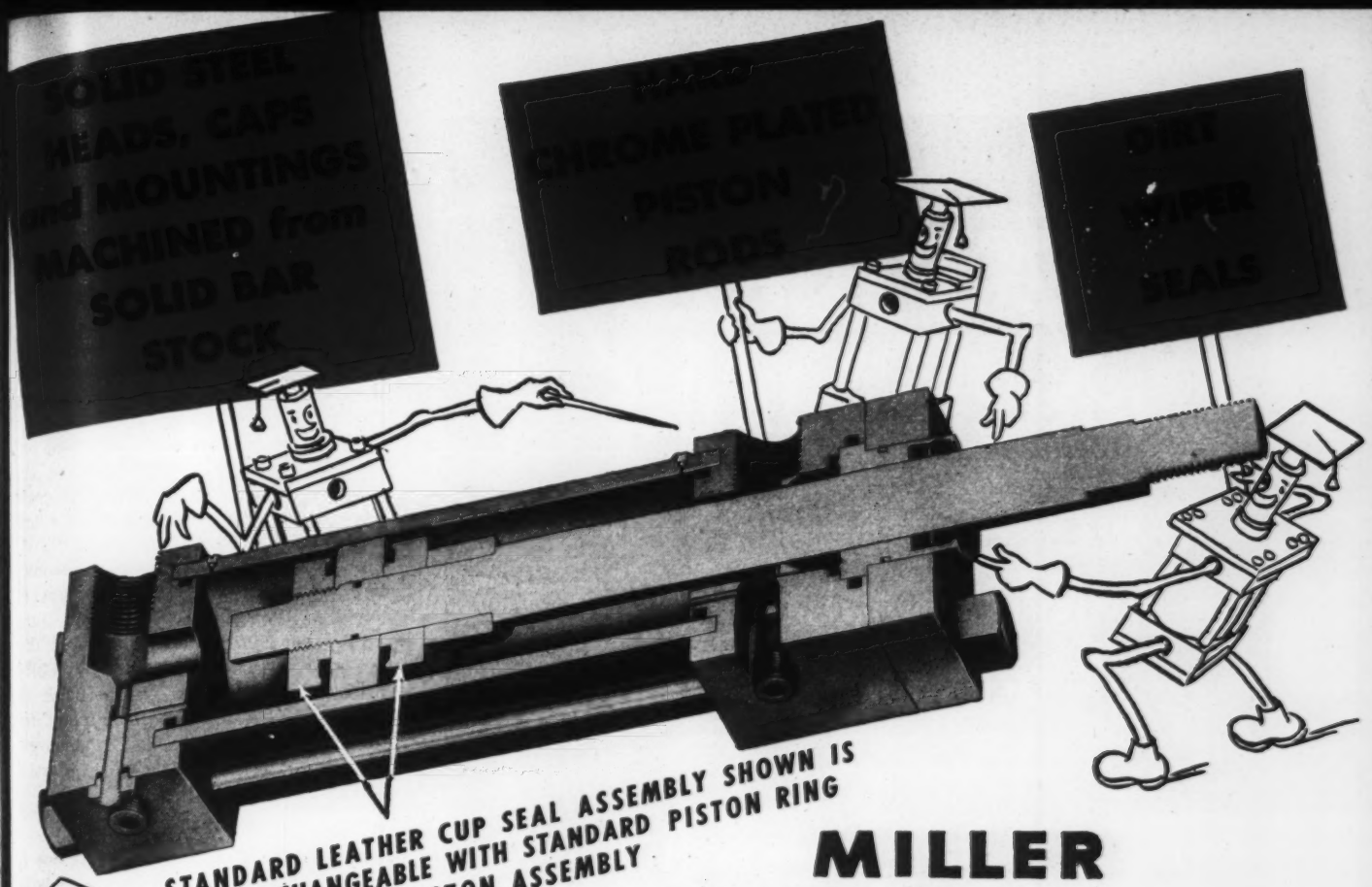
Third, there is the matter of personality. The complex industrial research projects of today require teamwork, a kind of sustained, intensive co-ordination that requires men who will work together. The ideal research man must have stamina and an attitude combining optimism, down-to-earth inquisitiveness, and a desire to co-operate with his fellow workers.

The man who knows a science, but who also has administrative ability, is a rare and precious find. He can plan a project, handle personnel and budget problems, explain his case to everyone, and carry an entire operation to a successful conclusion. He takes responsibility, both personal and professional, in his stride.

A good research man is more than a textbook with hands; he is a human being gifted with practical imagination. He treats facts with respect, since they are his tools, but he recognizes no boundaries for new and useful combinations of facts.

Research laboratories are searching diligently for new staff members who fulfill these requirements. Part of the future of this country depends upon how soon these men can be found, trained, and put to work.

From the September 1951 issue of The Frontier, *published by Armour Research Foundation of Illinois Institute of Technology, Chicago, Ill.*



STANDARD LEATHER CUP SEAL ASSEMBLY SHOWN IS INTERCHANGEABLE WITH STANDARD PISTON RING PISTON ASSEMBLY

MILLER
High Pressure
HYDRAULIC CYLINDERS
Meet J. I. C. HYDRAULIC STANDARDS

(Write for FREE copy of these "Standards")

Years before the Joint Industry Conference (J. I. C.) Standards for specifying "quality" hydraulic equipment were adopted, the *standard* design and construction features of Miller High Pressure Hydraulic (2000-3500 psi) Cylinders already included ALL the specifications for cylinders, seals and pistons now called for by the "Standards". Hard chrome plated, scratch-resistant piston rods and dirt wipers have long been standard Miller cylinder features yet are required by the "Standards" only under severe conditions.

Solid steel heads, caps and mountings which eliminate costly, dangerous breakage even under the severest operating conditions represent an "extra-quality" standard Miller cylinder feature which actually exceeds the high quality set by the J. I. C. Standards.

The Miller "Patented" Hydraulic Piston Rod Seal which has no manual adjustment and is automatically self-adjusting and wear-compensating to give life-long leakproof service without ever requiring any manual adjustment whatsoever . . . far surpasses the requirement of J. I. C. Standard H6.2.5 which specifies "Stuffing boxes for automatic packing shall be so designed as to prevent adjustment beyond the functional limits of the packing"

Write for illustrated cylinder bulletins A-105 and H-104

COMPLETE MILLER CYLINDER LINE INCLUDES: AIR CYLINDERS, 1½" to 20" BORES, 200 PSI OPERATION; LOW PRESSURE HYDRAULIC CYLINDERS, 1½" TO 6" BORES FOR 500 PSI OPERATION, 8" TO 14" BORES FOR 250 PSI; HIGH PRESSURE HYDRAULIC CYLINDERS, 1½" TO 12" BORES, 2000-3000 PSI OPERATION. ALL MOUNTING STYLES AVAILABLE.

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HARTFORD — NEW YORK CITY — DAYTON — ST. PAUL — FORT WAYNE — INDIANAPOLIS
MILWAUKEE — NASHVILLE — SEATTLE — LOS ANGELES — SAN FRANCISCO — BALTIMORE
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...and ONLY Parker has:

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- most extensive research facilities
- strictest quality-control processes
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Popularly used O-Rings stocked by authorized distributors in principal cities. Special Service O-Rings of tested and approved compounds supplied on order. Write now for new Parker Catalog No. 5100 which includes complete basic data on O-Ring sealing.

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News
OF MANUFACTURERS

ANNOUNCEMENT has been made by **Westinghouse Electric Corp.** of a $296,000,000 expansion program which will extend beyond 1953. This will be the second such program undertaken by the company since the end of World War II. Major projects already under way include a new plant in Raritan Township, N. J., which will manufacture electronics equipment; a small motor plant at Union City, Ind.; electronic tube plants at Elmira and Bath, N. Y.; and aircraft-armament plant at Baltimore; a jet engine parts plant at Columbus, O.; an expanded plant for generator output at East Pittsburgh, Pa.; and the purchase of a plastics plant at Hampton, S. C.

♦

Aluminum Company of America is expanding its research facilities with the erection of a new building at the aluminum research laboratories at New Kensington, Pa. The new unit will increase total floor space by about one-third and will be ready for occupancy early next year.

♦

Concurrent with its anneuncement of five new model fork lift trucks, **Towmotor Corp., Cleveland,** has released a sound-slide film entitled "What Makes It Tick?" Designed to provide information on the planning, designing and engineering incorporated in the building of Towmotor fork lift trucks, the film shows how the features of this equipment contribute to low-cost, efficient handling of materials.

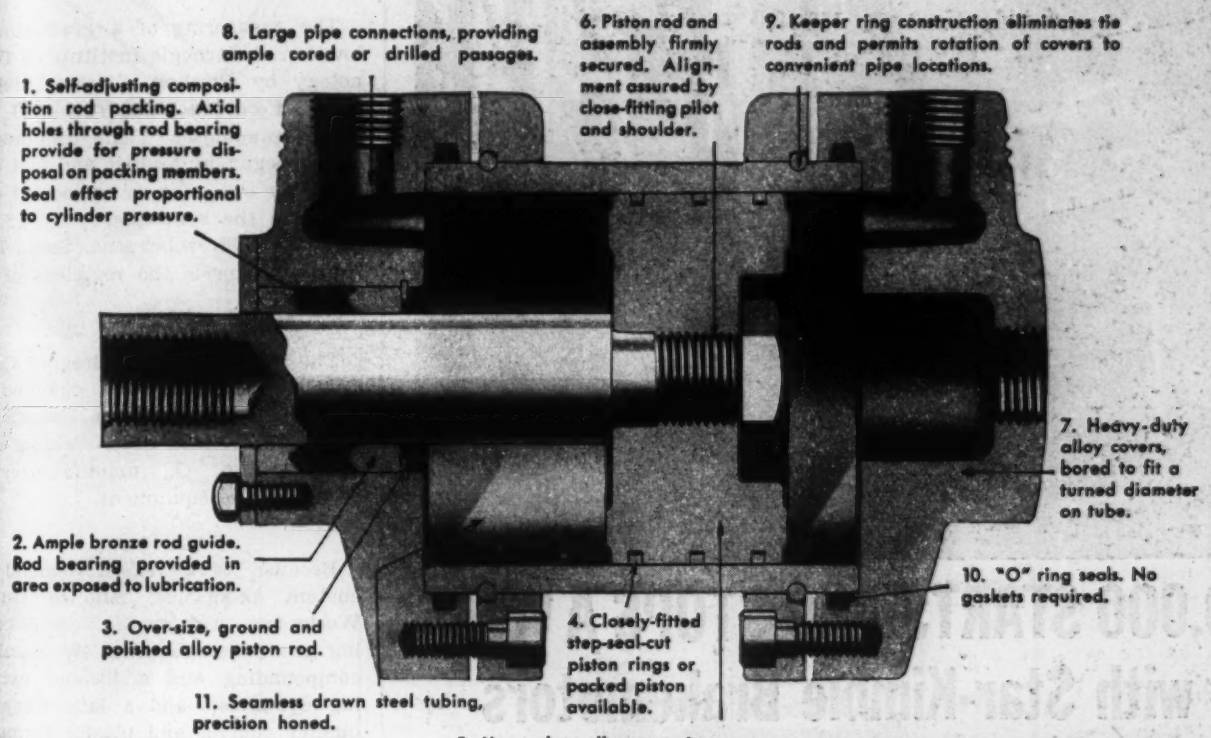
♦

A modern one-story plant, to be used for the fabrication of aircraft assemblies and components, is being constructed in Memphis, Tenn., by **Chicago Metal Hose Corp.** of Maywood, Ill. Production equipment is scheduled to be moved into the plant in January with full operation contemplated by March 1, when 60,000 sq ft, half of the total area, will have been completed.

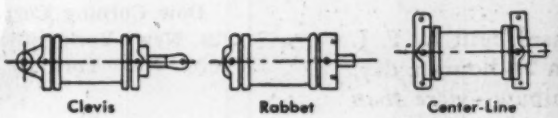
♦

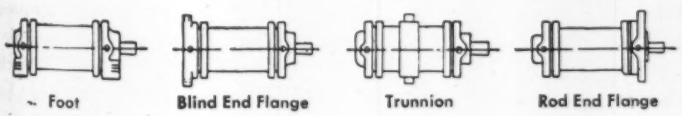
Sundstrand Machine Tool Co., Rockford, Ill., has started construction of a $700,000 addition to its manufacturing plant to provide space for increased defense production and to segregate Government production from the company's commercial man-

More Power to You


8. Large pipe connections, providing ample cored or drilled passages.
6. Piston rod and assembly firmly secured. Alignment assured by close-fitting pilot and shoulder.
9. Keeper ring construction eliminates tie rods and permits rotation of covers to convenient pipe locations.
1. Self-adjusting composition rod packing. Axial holes through rod bearing provide for pressure disposal on packing members. Seal effect proportional to cylinder pressure.
7. Heavy-duty alloy covers, bored to fit a turned diameter on tube.
2. Ample bronze rod guide. Rod bearing provided in area exposed to lubrication.
10. "O" ring seals. No gaskets required.
3. Over-size, ground and polished alloy piston rod.
4. Closely-fitted step-seal-cut piston rings or packed piston available.
11. Seamless drawn steel tubing, precision honed.
5. Heavy-duty alloy cast pistons with large bearing surfaces.

SEVEN STANDARD MOUNTINGS





..with RIVETT HYDRAULIC CYLINDERS

You'll find the performance of Rivett hydraulic cylinders close to foolproof. Designed with the utmost simplicity, they have no tie rods — keeper ring design permits covers to be rotated to convenient pipe connections and installation made in a minimum of space. External "O" rings are used as static seals to eliminate gaskets and assure leakproof operation. Sealing efficiency improves with increased pressure. Closely fitted automotive type piston rings reduce friction to a minimum.

Available in three pressure ranges: to 300 P.S.I. maximum and 1500 P.S.I. maximum service with standard models. 3000 P.S.I. maximum and higher services furnished on application. Seven standard mountings, in 10 bore diameters, in any stroke up to 96″, with standard size or 2:1 over-size piston rods, cushioned rod end, blind end or both. Special covers supplied. Send for Catalog Section 104.

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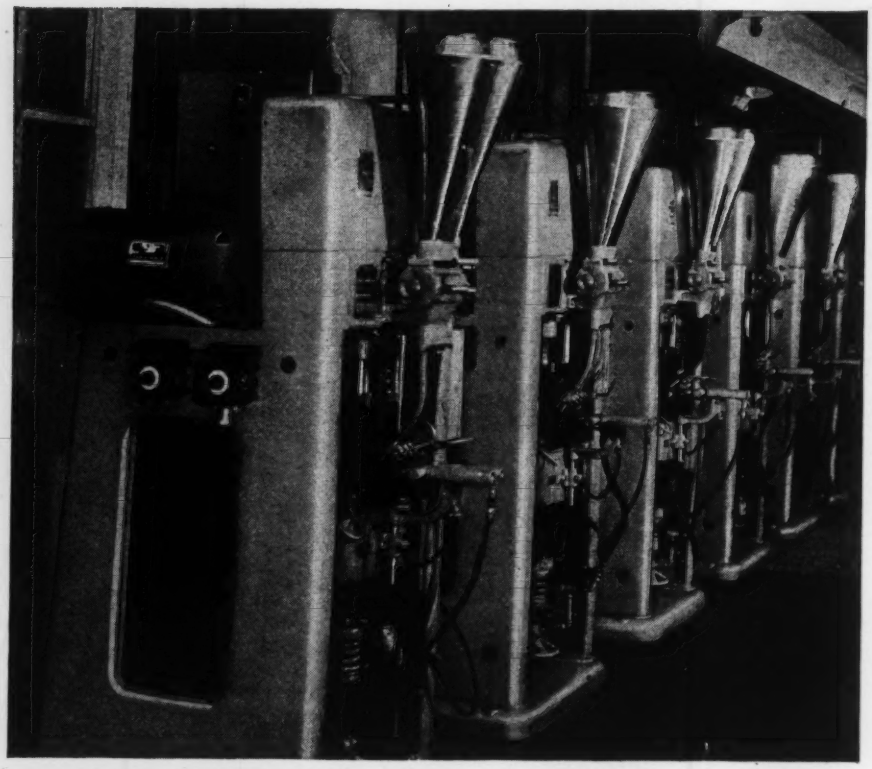
RIVETT furnishes a complete power package

VALVES • CYLINDERS • POWER UNITS

Air and Hydraulic
All sizes and types



20,000 STARTS-AND-STOPS A WEEK with Star-Kimble Brakemotors on Stokes Presses

These 15-ton fully-automatic molding presses built by F. J. Stokes Machine Company, Philadelphia, run 24 hours a day, 7 days a week. Motor reverses twice a minute—*more than 20,000 times a week!*

In service like that, conventional plugging methods would cause overheating and excessive stresses in the motor windings, greatly shortening its life. BUT . . . with Star-Kimble Brakemotors, there's no *need* for plugging! Fast braking action brings the motor to an instantaneous stop *before* current is applied in the reverse direction. Result: the Brakemotors stay on the job week after week, *year after year.*

Extra-large braking area provides *positive holding* to suspend load at upper limit of ram travel—and *immediate stopping* of down-travel when press is closed.

Star-Kimble Brakemotors are compact, integral units, with motor and brake *built* together to *work* together. Each Brakemotor is designed for its job by the pioneer makers of disc brakemotors, and backed by more than 25 years of experience.

For full information on construction and ratings, write for free Bulletin B-501-A.

STAR-KIMBLE

MOTOR DIVISION OF MIEHLE PRINTING PRESS AND MFG. CO.

201 Bloomfield Avenue Bloomfield, New Jersey

ufacture of transmissions, pumps and accessories. The addition will enlarge the present hydraulic division, providing 70,000 sq ft of floor space for shop use and 15,000 sq ft of office space. The new building is expected to be ready for use by next summer.

♦

The sponsoring of a graduate fellowship at Carnegie Institute of Technology by **Plaskon** division, **Libbey-Owens-Ford Glass Co.**, Toledo, O., has been announced. The fellowship, which began in August and will continue for one year, is concerned with work on the synthesis of 3,3′, 5,5′—terafluorohydrazobenzene. Samuel Allen Heininger is the recipient of the fellowship.

♦

The name of Morton-Gregory Corp., Toledo, O., has been changed to **Gregory Industries Inc.**, which includes the Nelson Stud Welding division, Lorain, O., manufacturer of fasteners and equipment.

♦

Because of increased demand for custom extrusions, **Auburn Button Works Inc.**, Auburn, N. Y., is expanding production facilities by installing compounding and additional extruding equipment and a laboratory for quality control and plastic formulating.

♦

Dow Corning Corp. recently moved its New York office to 600 Fifth Ave., New York 20, N. Y.

♦

The Atomic Energy Commission has extended for five years the **General Electric Company's** contract for operation of the Hanford, Wash., Works and the Knolls Atomic Power Laboratory, Schenectady, N. Y.

♦

The Aro Equipment Corp., Bryan, O., has purchased Pyles Industries Inc. of Detroit. The new corporation will be operated as an Aro subsidiary.

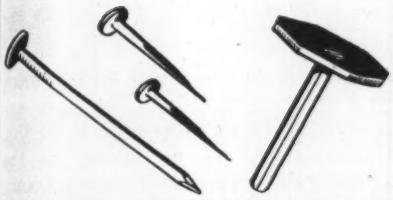
♦

Purchase of the Frictionless Metal Co. of St. Louis has been announced by Federated Metals division of **American Smelting and Refining Co.** Federated is now producing Frictionless bearing metal exclusively at its St. Louis plant.

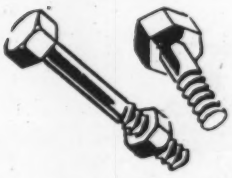
♦

An expansion of the power-driven brush manufacturing facilities of **Pittsburgh Plate Glass Co.** began recently in Baltimore, Md. Manufacturing power-driven metal and fiber brushes since 1931, the company has utilized space in its adjoining paint and varnish brush producing factory

COPPER NAILS and TACKS
COPPER STORM NAILS



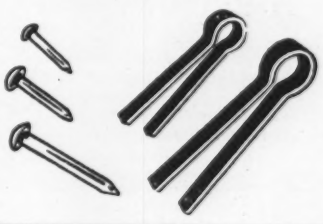
BRASS and BRONZE
BOLTS and NUTS



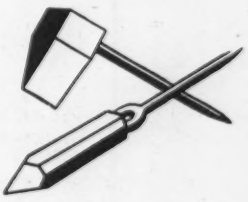
BRASS and BRONZE CAP
and LAG SCREWS

BRASS and COPPER RIVETS
and WASHERS

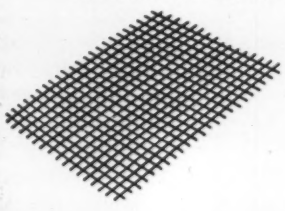
BRASS COTTER PINS
BRASS ESCUTCHEON PINS



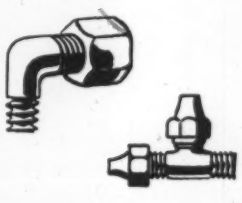
SOLDERING COPPERS



INDUSTRIAL WIRE CLOTH and
BRASS STRAINER CLOTH

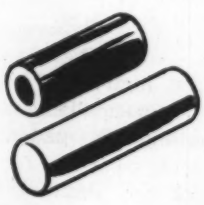


AUTOMOTIVE and
INDUSTRIAL FITTINGS



COPPER HAMMERS

BEARING BRONZE BARS



Miscellaneous items of copper and brass for M-R-O

at CHASE

Need Bearing Bronze Bars? Brass or Bronze Bolts? Copper Nails? Any other Brass or Copper Items for Maintenance—Repair—Operating Supplies? We can supply many such items under CMP Reg. 5 to any business enterprise, government agency, or public or private institution, on a DO-MRO rated order for such uses, subject to the end use restrictions established by the NPA.

Chase offices (23 of them warehouses) located in major industrial centers, coast to coast, stand ready to serve you. Phone the one nearest you. They'll make every effort to fill your "DO" orders from stock or as soon as possible, if not from stock.

Chase BRASS & COPPER

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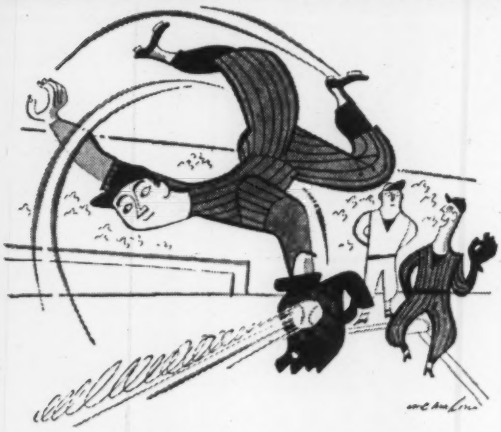
Boston	Dallas	Indianapolis	Minneapolis	Philadelphia	St. Louis	(†sales office only)



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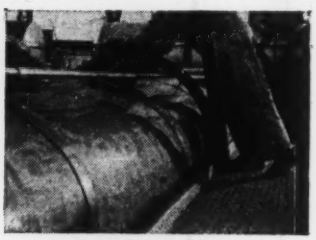

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STOCKED BY LEADING STEEL WAREHOUSES

for this operation. The new plant will be a single story structure measuring approximately 193 by 125 ft, and is expected to be completed before the end of this year.

♦

Purchase of the Webb Wire Works, New Brunswick, N. J., has been announced by **The Carpenter Steel Co.**, Reading, Pa. To be known as the Webb Wire division of the parent company, the plant manufactures needle wire, stainless steel spring wire, and other specialties in small diameters down to 0.0025-inch.

♦

The Raymond Corp., Greene, N. Y., has acquired a plant at nearby Morris, N. Y., for production of its materials handling equipment. The firm has also expanded operations at its main plant.

♦

Plans for the construction of a $3,000,000 plant in Wooster, O., for the manufacture of electrically driven hydraulic and fuel pumps for jet engines have been announced by **Borg-Warner Corp.** Production in the 104,000-sq ft factory is expected to be under way next spring.

♦

With the growth of its line of diamond abrasive materials, the **Elgin National Watch Co.**, Elgin, Ill., has organized a new abrasives division. In addition to diamond abrasives, the new division will market a line of accessories normally required in fine finishing operations.

♦

Formation of a special department to handle an increased number of military contracts has been announced by **Bausch & Lomb Optical Co.**, Rochester, N. Y. The new Defense Contract department is designed to maintain "closer liaison with U. S. Defense Department representatives and expedite the handling of contracts for special optical equipment."

♦

Construction has begun that will increase gear manufacturing capacity by 30 per cent at the Lynwood, Calif., plant of **Western Gear Works**. This addition is the first in a series of expansion moves planned for this southern California plant of the company. A new plant is also under construction at Belmont, Calif.

♦

The first high-speed heat processing line for normalizing welded steel pipe continuously under automatic control will be built for the **Lone Star Steel Co.** plant at Lone Star, Tex., by **Selas Corp. of America.**

The problem was...

How to get extra copies of blueprints—

fast!

A case history based on the experience of the American Brake Shoe Company, Kellogg Division, Rochester, N. Y.

The blueprints (and direct-process prints) submitted by customers placing machining orders used to be a problem for the Kellogg Division, American Brake Shoe Company.

Invariably, prompt delivery was requested. But... before production could begin, extra copies of each customer-print were needed. Being semi-opaque, these prints could not be used as print-making masters in Kellogg's direct-process machine. How, then, could the extra copies be obtained in the shortest time... and at the lowest cost?

Kodagraph Autopositive Paper was the answer.

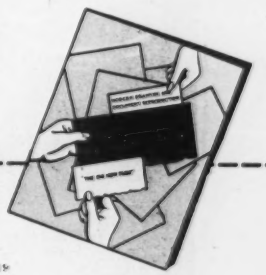
Now... extra copies are made quickly... economically

With Kodagraph Autopositive Paper, Kellogg reproduces the blueprints, direct-process prints, and other types of "originals" *directly*... quickly obtains the print-making masters that are needed so urgently.

The operation is simple... is performed under ordinary room light. Autopositive Paper is exposed in contact with the customer's print in Kellogg's direct-process machine. It is then processed in standard photographic solutions. The result is a sparkling, long-lasting, highly legible photographic reproduction—dense blacks, clean whites—on a durable, evenly translucent paper base. From this Autopositive intermediate, the required number of extra copies can be turned out... at practical, uniform machine speeds.

Kodagraph Autopositive Paper

"THE BIG NEW PLUS" in engineering drawing reproduction



It enables you, or your blueprinter, to produce photographic intermediates directly, at a new low cost, without an extra step.

It enables you to protect valuable originals from wear and tear.

It gives you photo-lasting file copies.

It restores old, worn drawings . . . reproduces opaques.

MAIL COUPON FOR FREE BOOKLET

EASTMAN KODAK COMPANY
Industrial Photographic Division, Rochester 4, N. Y.

Gentlemen: Please send me a copy of your illustrated booklet giving all the facts on Kodagraph Autopositive Paper.

Name_____ Position_____
(please print)

Company_____

Street_____

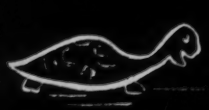
City_____ Zone_____ State_____

Kodak
TRADE-MARK

LAUSON ENGINES
ARE BUILT TO Last!

Extra attention is given to the materials and engineering that go into every Lauson engine—refinements such as automotive-type pistons, simultaneous cooling of both valves, safe, sure fly-ball governors, and selected long-life bearings . . . refinements that add up to . . . smoother running, trouble-free operation, and more hours of power! The most surprising feature of all is that Lauson engines cost no more than ordinary engines!

THE oldest NAME IN PORTABLE ENGINES!



Over 50 years of experience go into every Lauson engine . . . a priceless tradition of know-how and engineering excellence unequaled in the field! . . . another reason why Lauson is the greatest name in portable engines!

OUTBOARD MOTORS
LAUSON
PORTABLE ENGINES

THE LAUSON COMPANY New Holstein, Wis., U. S. A., Div. of Hart Carter Co.
In Canada: Hart-Emerson Co. Ltd., Winnipeg

Philadelphia. Designed to accommodate a wide range of pipe sizes, the line will be integrated with other pipe-making equipment to form an uninterrupted production line.

♦

National Broach & Machine Co., manufacturer of gear finishing and inspection machines, broaches, broaching fixtures and special production machines, has recently moved into its new administration building at Shoemaker and St. Jean Aves., Detroit. The new structure provides an additional 24,000 sq ft of floor space for offices and engineering department; the space formerly used for this purpose is now being used for manufacturing.

♦

The general offices and research laboratories of the **Metal Removal Co.** are now located in a new 15,000-sq ft building at 1546 N. Orleans St., Chicago, Ill.

♦

A new structure adjoining the home office and plant of **All-State Welding Alloys Co. Inc.,** White Plains, N. Y., more than doubles the factory area. It houses modern equipment for extruding, flux coating, cleaning, straightening, cutting, drying and packaging. In addition it provides expanded laboratory and engineering facilities for the company's technical division, serving the needs of all distributors.

♦

H. K. Porter Co. Inc., Pittsburgh, recently purchased the Buffalo Steel Co., Tonawanda, N. Y. The latter company has a total capacity of more than 70,000 tons of light steel products a year.

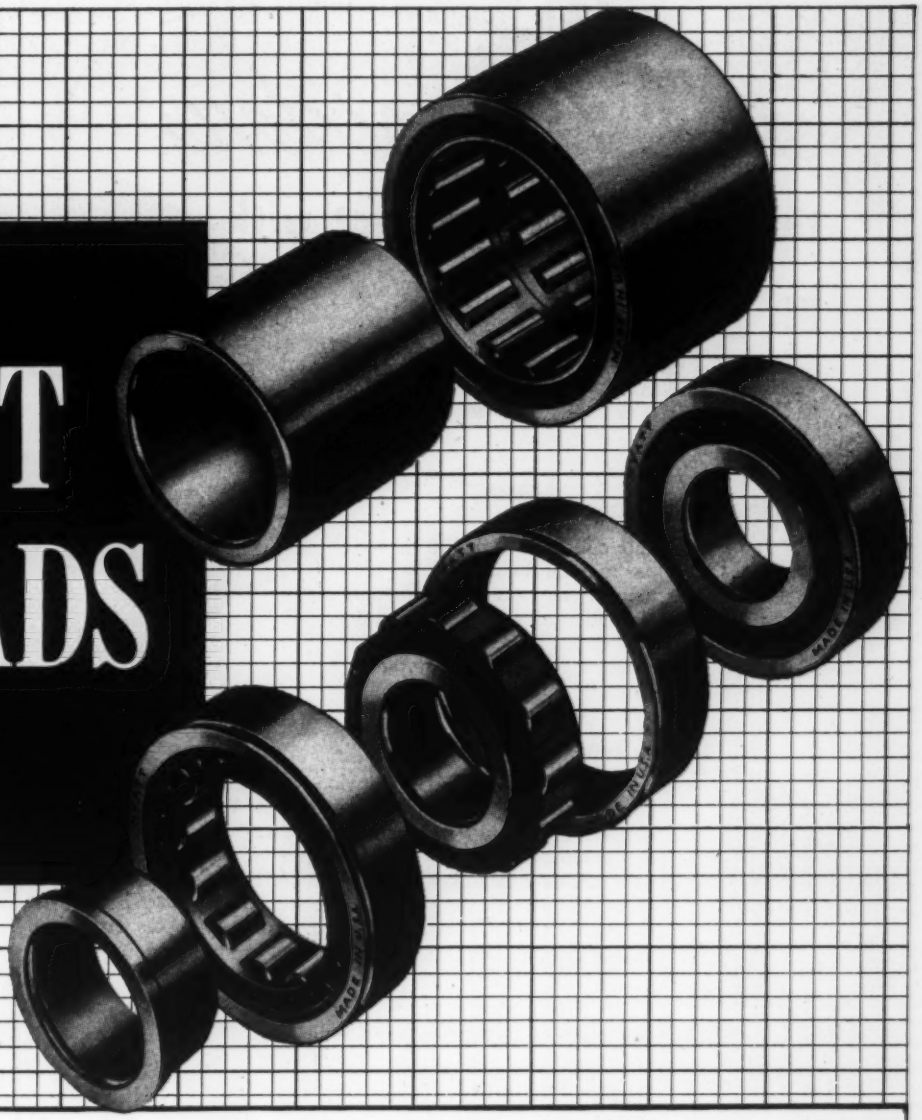
♦

A license for the manufacture of molecular bonded bimetallic pistons has been granted by the Al-Fin division of the **Fairchild Engine and Airplane Corp.** to the **Zollner Machine Works,** Fort Wayne, Ind. Under the terms of the license agreement, the **Aluminum Company of America** and the **Bohn Aluminum and Brass Corp.** will use the patented Al-Fin process in bonding and casting operations in production of piston castings for Zollner.

♦

Engineering honors and cash awards totaling $5000 have been given by the **Lincoln Arc Welding Foundation** of **Cleveland,** to 63 young engineers in 28 different states, representing 5 different engineering schools. Funds totaling $1750 were also awarded to three engineering schools to establish

HYATT HY-LOADS



Your best bearing bets

THE Hyatt Hy-Load line of cylindrical roller bearings, for radial loads or light or intermittent thrust loads, are made in two diameter series, wide and narrow widths, and to standard boundary dimensions.

There are ten different types of Hyatt Hy-Load Roller Bearings. Four have separable inner races, two have separable outer races, and four are non-separable. There is also the duplex, or double-row type of Hyatt Hy-Load with a separable inner race.

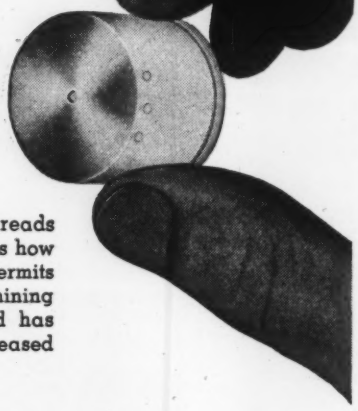
* * *

Wide flexibility in design and assembly procedures is possible with Hyatt Hy-Load Bearings. They are designed and built to do most any bearing job and they are your best bet to do that job right. Specify Hyatt Hy-Loads for your new machine design. Hyatt Bearings Division, General Motors Corporation, Harrison, N. J.

HYATT ROLLER BEARINGS

Consider

the advantages you get with nylon rod....



This coil form with 128 threads per inch on the O.D. shows how nylon's machinability permits close tolerance work. Machining coil forms from nylon rod has resulted in greatly increased strength of threads.

Because of the STRENGTH of nylon rod, bearing retainers and screws are being machined from it. WEAR RESISTANCE is important for parts like gears; and where lubrication is difficult, nylon gears are outlasting metal gears by as much as 2 to 1. The SELF-LUBRICATING properties of parts machined from nylon rod contribute to long and QUIET OPERATION of gears, bearings, thrust washers, etc. The production advantages of nylon rod are tremendous—

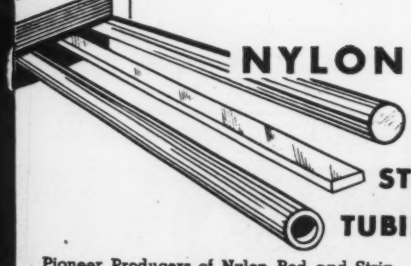
Rush Production—No waiting for costly molds when you machine parts from nylon rod.

Design Flexibility—You can change a part's design by merely changing the machining set-up.

Close Tolerances—Particularly in heavy cross-sections, machining gives closer tolerances than are possible by molding nylon.

New Folder Contains Complete Information on sizes, nylon formulations and colors available, etc. Write for your copy.

THE POLYMER CORPORATION
Reading, Pennsylvania



NYLON and TEFLON
ROD
STRIP
TUBING

Pioneer Producers of Nylon Rod and Strip

scholarships in honor of and named for the engineers receiving the main awards. The awards were made in the fourth annual competition of the Foundation's Engineering Undergraduate Award and Scholarship program. The program offers awards for papers by engineering undergraduates on the design, fabrication, research or maintenance of machines or structures in which arc welding is used. The Foundation is sponsoring a ten-year series of programs to encourage undergraduate engineers to use imagination and ingenuity in developing engineering projects.

♦

The United States Rubber Co. has acquired the assets of the Chicago Die Mold Manufacturing Co., Chicago, custom molder of plastic products. The business will be operated as Chicago Die Mold division of the parent company. Production facilities will be expanded to manufacture industrial products from United States Rubber's new plastic compounds, Uscolite and Enrup.

♦

National Machine Products Co. recently announced its removal to Utica, Mich.

♦

Plans for over $5,000,000 in additions to plant and equipment of **The American Welding & Manufacturing Co.**, Warren, O., were announced recently. This expansion will permit the company to increase its production of jet and reciprocating aircraft engine parts.

♦

Westinghouse Air Brake Co. has purchased all of the stock of Melpar Inc. of Alexandria, Va., and Cambridge, Mass. The latter company is actively engaged in the research and development programs of the Armed Services, including prime contracts with the Air Force, Navy and Signal Corps covering the fields of radar, sonar, communications, guided missiles, computers and miniaturization.

♦

As a result of increased demand for machine and cutting tools, **Charles H. Besley and Co.** is building a modern one-story plant in South Beloit, Wis., which will house both divisions of the company. Productive capacity will be increased approximately 100 per cent.

♦

Precision Metalsmiths Inc., producer of impellers, rotors and stators for aviation, radar, wave guides and jet engines, recently moved into new larger quarters at 1081 East 200th St., Cleveland 17, O.

Case History H-107

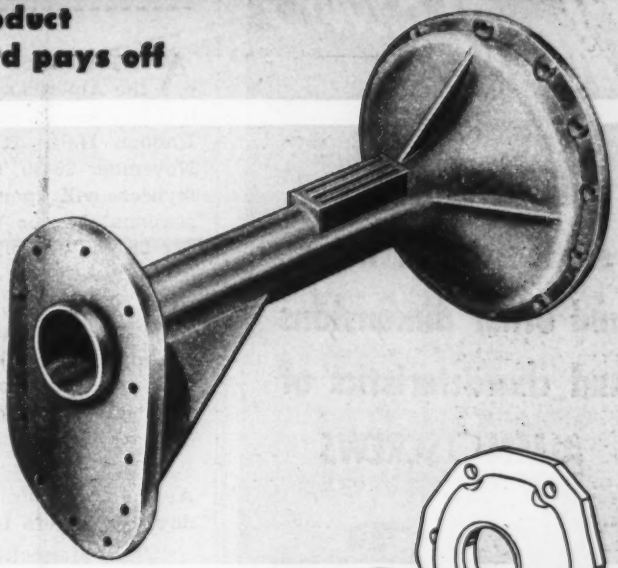
Here's what we mean by SUPERIOR ENGINEERED FOUNDRY PRODUCTS...

. . . an example of how proper product development at the drawing board pays off

PROBLEM:

Tractor Drive Spacers were required in five different sizes, making them expensive to produce as one-piece steel castings. Each size would require:

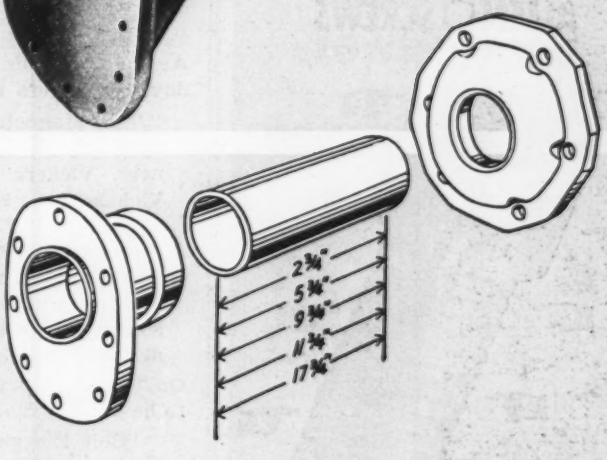
1. A separate set of expensive core boxes and pattern equipment.
2. A separate set of flask equipment . . . expensive cleaning and handling procedure.
3. A separate machining setup . . . expensive jigs and fixtures.
4. An excessive amount of critical steel . . . average weight would be 52.5 lbs.



OUR SOLUTION:

FOUNDRY ENGINEERED CAST-WELD CONSTRUCTION

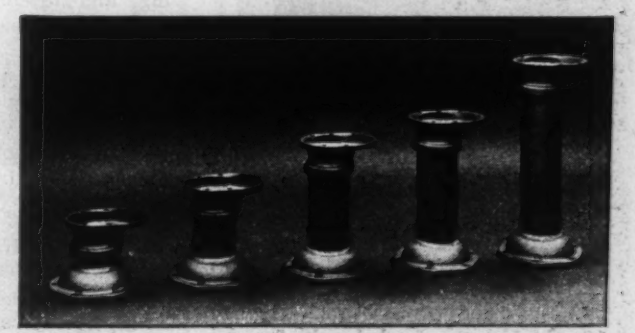
Two simple machined steel castings plus one piece of pipe cut to required length and welded to the castings equals five different sizes of Spacers.



RESULT: 38.4% SAVINGS

Tractor Drive Spacers are being made in the five sizes by our foundry at a greatly reduced cost. All that is required is:

1. One set of inexpensive pattern equipment and one core box.
2. Only one size of flask equipment . . . simplified cleaning and handling.
3. One machining setup . . . one set of jigs and fixtures.
4. Less steel . . . average weight reduced to 37.1 lbs.



These assemblies have been proved in tough tractor service.

TOTAL COST OF PART REDUCED 38.4%

YOU, TOO, CAN GET SAVINGS LIKE THESE! CONSULT OUR PRODUCT DEVELOPMENT SECTION REGARDING YOUR PROBLEM . . . WHILE IT'S STILL ON THE DRAWING BOARD

Let our foundry engineers help you conserve critical materials.

ENGINEERED FOUNDRY PRODUCTS Since 1916

SUPERIOR STEEL AND MALLEABLE CASTINGS CO.

BENTON HARBOR, MICHIGAN, U. S. A.

TO KEEP YOUR CASTINGS COMING . . . KEEP YOUR SCRAP GOING TO THE FOUNDRIES

NOW scientific
Chart Control
maintains
definite quality
standards for these
and other dimensions
and characteristics of
ALLEN SCREWS

1. Head radii
2. Head diameter
3. Body diameter
4. Thread form
5. Lead error
6. Thread size
7. Rockwell hardness
8. Head - Body - Thread concentricity
9. Head height
10. Socket size and depth

WARNING
Allen-Type screws aren't necessarily Allen-Made.
Get genuine "Pressur-formed" Allen Head screws in this black and silver box.

THE ALLEN MANUFACTURING COMPANY

Society
ACTIVITIES

AT THE 1951 annual meeting of the **American Society of Mechanical Engineers** to be held at Chalfonte-Haddon Hall, Atlantic City, N. J., November 26-30, the Machine Design division will sponsor three technical sessions—two on Wednesday, November 28 and one on Thursday, November 29. At 9:30 a.m. on Wednesday these papers will be presented:

"Contributions to Hydraulic Control," by Shih-Ying Lee and John F. Blackburn, research engineers, Dynamic Analysis and Control Laboratory, Massachusetts Institute of Technology.

At the 2:45 p.m. session on Wednesday, the papers to be presented are:

"The Magnetic-Particle Clutch," by Philip H. Trickey, chief engineer, Vickers Electric Division, Vickers Inc., St. Louis, Mo.

"Design of Flat-Wound Tension Springs," by R. M. Conklin, supervisor, mechanical-engineering division, and Donald R. Ferry, research engineer, Battelle Memorial Institute, Columbus, O.

On Thursday at 9:30 a.m., the papers to be presented are:

"Bolt Elongations and Loads," by Leonardt F. Kreisle, assistant professor, mechanical engineering, and Joseph B. Oliphint, research engineer, University of Texas;

"Hysteresis of Shaft Materials in Torsion," by W. P. Welch, section manager, Westinghouse Electric Corp., East Pittsburgh, Pa., and B. Cametti.

♦

The annual $750 award made by the **American Welding Society** for the best paper on resistance welding was won by W. Leslie Roberts of the Westinghouse Research Laboratories.

♦

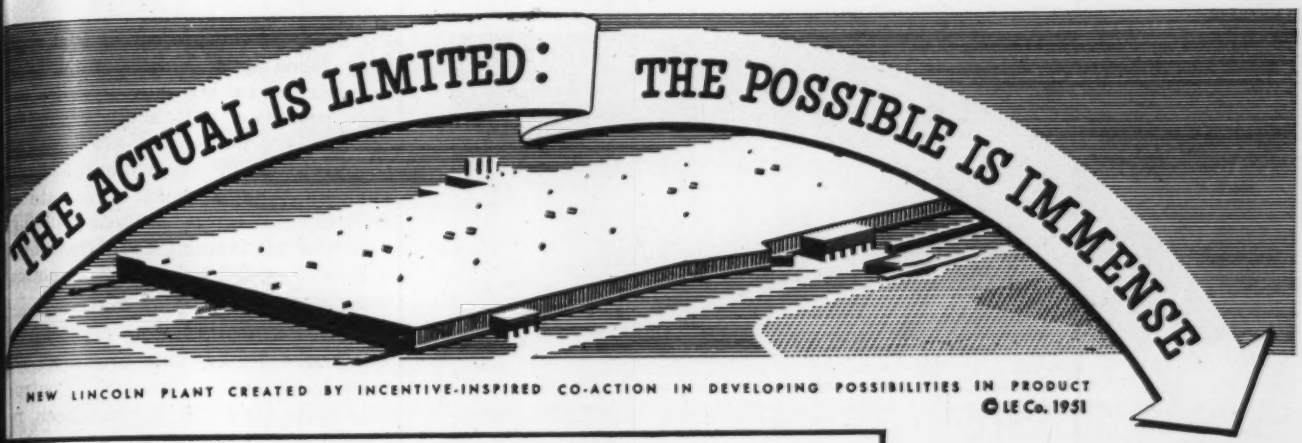
Technical sessions of the annual meeting of the **Society for Experimental Stress Analysis** at Hotel Bellevue-Stratford, Philadlephia, Pa., will be held Wednesday, Thursday, and Friday, November 28, 29, and 30, morning and afternoon. A Symposium on November 29 will comprise a panel discussion on Education and Training for Experimental Analysis: an executive will point out what management expects from experimental analysts; an industrial engineer will explain

ONLY
Leading Industrial Distributors
. . . can offer you the advantages of ALLEN HEAD PRODUCTS

Cap screws . . . . . Set screws
Shoulder screws . . . Allenuts
Flat head cap screws . . Keys
Dowel pins . . . . Pipe plugs

Plus . . .
The important help that an experienced supplier can give you in times of shortage.

YOUR ALLEN DISTRIBUTOR



NEW LINCOLN PLANT CREATED BY INCENTIVE-INSPIRED CO-ACTION IN DEVELOPING POSSIBILITIES IN PRODUCT

© LE Co. 1951

WELDED DESIGN ALWAYS IMPROVES PRODUCT AND LOWERS COST

Welded Steel Design

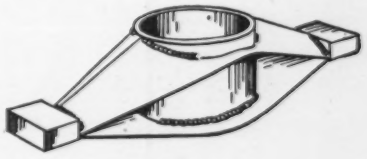


Fig. 1—Increases Rigidity 200% *by redesigning this End Bearing Bracket to welded steel. Cost is cut from $1.52 to 75 cents over construction shown in Fig. 2* . . . a saving of 51%.

Original Design

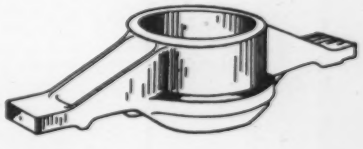


Fig. 2—Original Construction *required 87% more metal than present welded steel design. Initial weight was 3¼ pounds . . . welded steel design (Fig. 1) weighs only 2 pounds.*

STEEL IS TWICE AS STIFF

. . . achieves equal rigidity with half the material

CONTRARY to erroneously preconceived notions, steel is twice as rigid as iron. In the simple demonstration shown in Fig. 3, a bar of steel deflects only half as much as a bar of iron stressed under equal load.

When designing a machine component for equal stiffness with steel, weight generally should be cut 50% or more. Otherwise, the design has not been developed far enough to fully utilize the superior physical properties of steel.

Welded steel has several additional benefits that improve product durability. Steel is 3 times stronger . . . has four times the resistance to fatigue. Steel is also ductile . . . withstands impact and shock without fracturing.

Your Lincoln Welding Engineer will gladly demonstrate how to apply these basic, cost-saving advantages to your products. Write The Lincoln Electric Co., Cleveland 1, O.

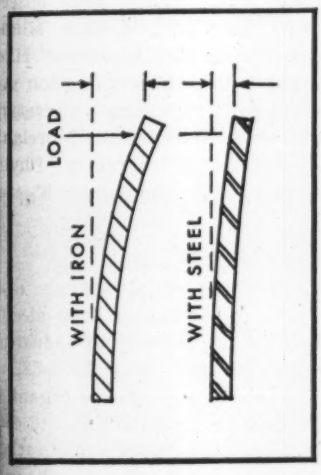


Fig. 3—Steel deflects only half that of iron *under equal loading. 50% of the material is generally required to duplicate stiffness.*

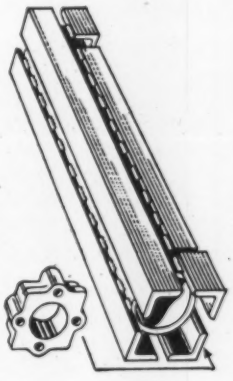


Fig. 5—Maintains alignment *to within .005" on this 120" long machine frame member. Machining time was cut from 8 hours to 2¼ hours and 170 pounds of metal saved on each frame member.*

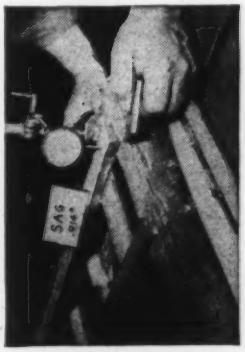


Fig. 4—Design in steel cuts deflection 80%. *Originally the top for this planer deflected .070". With the present, welded steel construction, the deflection is only .014". Weight has been reduced from 410 pounds to 320 pounds.*

HERE IS PROOF

Machine Design Sheets are available to designers and engineers. Simply write on your letterhead to Dept. 110,

THE LINCOLN ELECTRIC COMPANY

CLEVELAND 1, OHIO

the needs of the project or test engineer faced with a specific problem in experimental stress analysis; a college professor will show what the colleges are doing and are prepared to do to train experimental stress analysts; and a recent graduate in experimental stress analysis will suggest how his training could have been improved in the light of his practical experience.

♦

Beatrice Hicks, vice president and chief engineer of Newark Controls Co., Bloomfield, N. J., has been re-elected, for a second term, president of **Society of Women Engineers** for 1951-1952. The other new officers are: vice president, Lillian Murad, Muratex Chemicals; treasurer, Hilda Edgecomb, Rural Electrification Administration; recording secretary, Barbara Cain, Jackson & Moreland; and corresponding secretary, Phyllis Evans Miller, Westinghouse Electric Corp.

♦

New York industrial designer Russel Wright has recently been elected president of the **Society of Industrial Designers** for the year 1951-52, at the annual meeting of the organization. It was also decided at the conference that the Society's publication, *U. S. Industrial Design,* be changed from an annual book to a quarterly magazine. The first issue will be in January, 1952.

♦

The **American Standards Association** Subcommittee Y10.2 (formerly Z10.2), *Letter Symbols for Hydraulics,* has recently been reconstituted for the purpose of reviewing and revising the 1942 Standards on Letter Symbols for Hydraulics. The committee would appreciate receiving comments from interested parties concerning the 1942 Standards and any suggested additions or modifications. Suggestions and comments should be directed to the Chairman, Dr. J. M. Robertson, P. O. Box 30, State College, Pa.

♦

Dr. Norman A. Skow, Director of Research, Synthane Corp., Oaks, Pa., is the new chairman of the advisory technical committee of the laminated products section of the **National Electrical Manufacturers Association.** John C. Pitzer, Engineering Dept., The Formica Co., Cincinnati, O., will serve as Vice Chairman. Among important activities under consideration by the committee are: co-operation with various Military Services in the co-ordination of military and federal specifications and industry standards for laminated products; study of phys-

Production stamina, tool-room accuracy ..lathe gets both with TIMKEN® bearings

THIS "Economy" lathe is designed to fill a specific demand for a medium-priced lathe which has these two qualities: ruggedness for general production work and accuracy for tool-room service. To insure these two qualities, Rockford Machine Tool Co. mounts the spindle and gear shafts on Timken® tapered roller bearings.

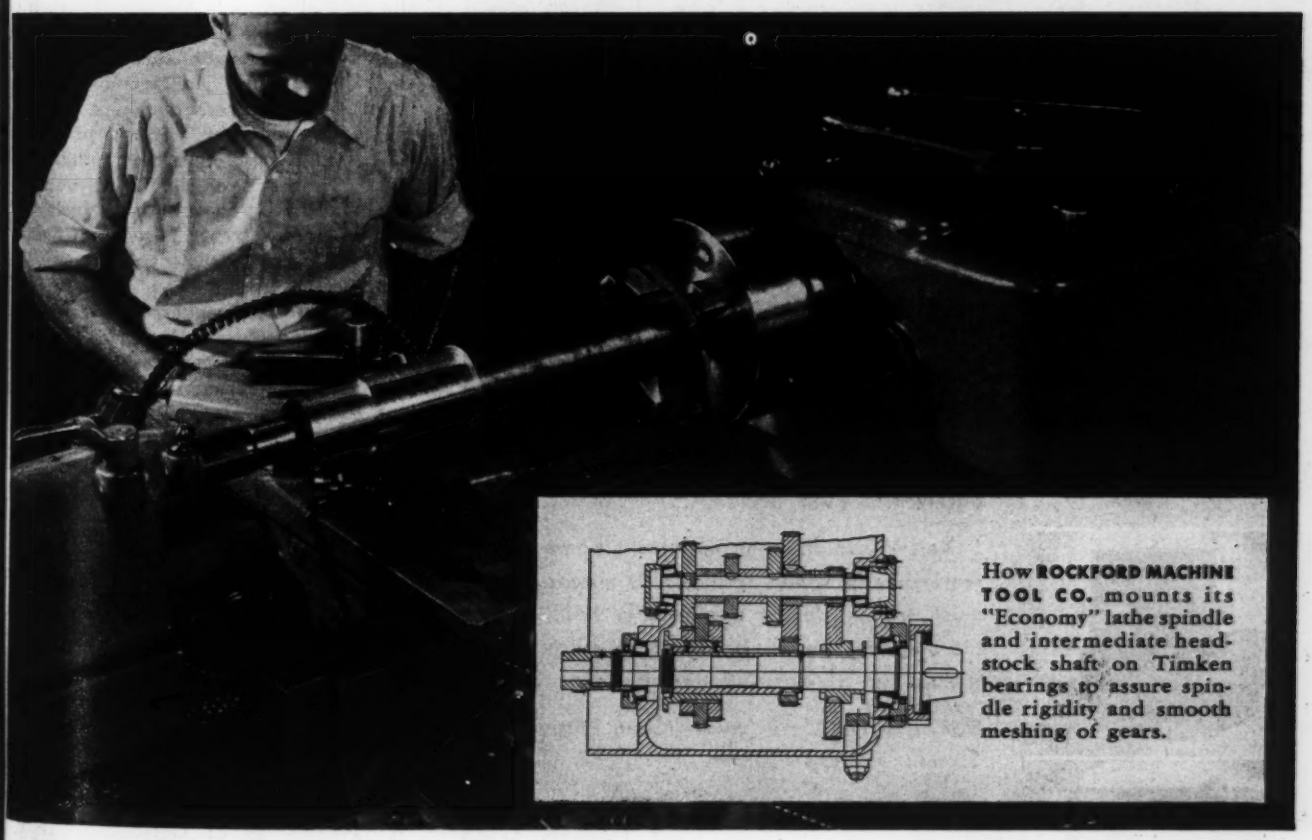
With Timken bearings, the spindle is held in rigid alignment. Precision is maintained. Gears mesh smoothly — with minimum wear even under the heaviest loads.

Because of their tapered construction, Timken bearings take radial and thrust loads in any combination. Line contact between rollers and races provides extra load-carrying capacity. The true rolling motion and incredibly smooth surface finish of Timken bearings practically eliminate friction.

Timken bearings hold shaft and housing concentric, making closures more effective. Because they are (1) precision manufactured, (2) engineered for the job, (3) made of Timken fine alloy steel, Timken bearings normally last the life of the machine.

When you buy or build machine tools, be sure they are equipped with Timken bearings. No other bearing can give you all the advantages of the Timken bearing. Look for the trade-mark "Timken". The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ont. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.



How **ROCKFORD MACHINE TOOL CO.** mounts its "Economy" lathe spindle and intermediate headstock shaft on Timken bearings to assure spindle rigidity and smooth meshing of gears.

FINISHED TO CLOSER TOLERANCES

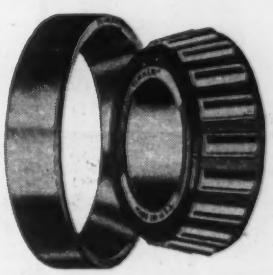
Finishing to incredible smoothness accounts for much of the precise, smooth rolling performance of Timken bearings. This honing operation is typical of the amazingly accurate manufacturing methods of the Timken Company.

The Timken Company is the acknowledged leader in: 1. advanced design; 2. precision manufacturing; 3. rigid quality control; 4. special analysis steels.

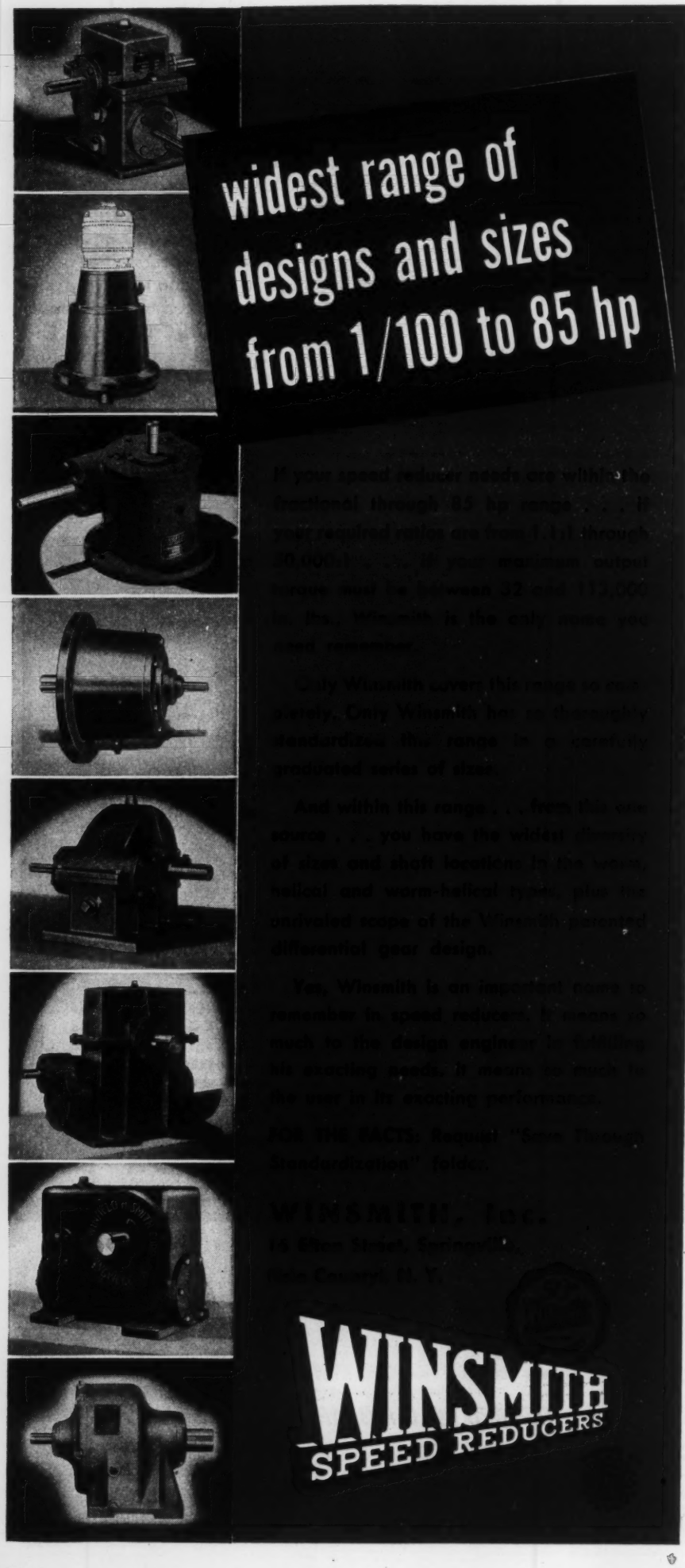
TIMKEN

TRADE-MARK REG. U.S. PAT. OFF.

TAPERED ROLLER BEARINGS



NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL ◧ AND THRUST →◨← LOADS OR ANY COMBINATION →◎←



ical properties, including hot Rockwell impact data, influence of thickness on dielectric strength and dissipation factor, loss factor, rods and tubes, 60-cycle power factor and the development of new standards.

♦

The **American Chemical Society** has announced the winner of the $1000 Scientific Apparatus Makers Award in Chemical Education. Dr. Joel H. Hildebrand, dean of the Department of Chemistry, University of California, is to receive this award. Founded in 1950 by the Scientific Apparatus Makers Association, the award recognizes outstanding contributions to chemical education.

♦

The Annual Doehler Award of the **American Die Casting Institute** was presented recently to the authors of the *Safety Manual for the Die Casting Industry*. Established in 1949, this award is made each year "for the outstanding achievement contributing to the advancement of the die casting industry." It was presented to Charles A. Sanford, Industrial Relations manager of the Cleveland Hardware and Forging Co., Cleveland, O.; Norman Dress, personnel manager of Precision Castings, Inc., Cleveland; and Byron S. Van Horn, safety director of the Doehler-Jarvis Corp., New York. These three men were directly responsible for the compilation and publication of the Die Casting Industry Safety Manual.

♦

Warden F. Wilson, general sales manager of the Lebanon Steel Foundry, Lebanon, Pa., has been elected president of the **Alloy Casting Institute,** national technical organization of leading producers of stainless steel castings.

♦

American Gear Manufacturers Association, with headquarters at 301 Empire Building, Pittsburgh, Pa., announced the appointment of John C. Sears as Executive Secretary of the Association as of October 1, 1951. Mr. Newbold C. Goin, former Executive Secretary, has joined the management consulting firm of Brenholts, Goin & Ogg.

♦

Dr. Harold L. Maxwell, Supervisor of General Consultants, E. I. du Pont de Nemours & Co. Inc., Wilmington, Del., has been elected a vice president to fill a vacancy on the board of the **American Society for Testing Materials.** He will serve through the Society's 50th Anniversary Meeting in New York City, June, 1952.

Cork-and-Rubber Gasket Materials

made to meet government specifications

You can get samples from Armstrong of materials made to meet each class of the principal government specifications covering cork-and-rubber gasket materials. These materials are listed below.

Specification	Material	Specification	Material
MIL-G-6183			
Type I Soft	NC-709	Type II Soft	DC-167
Type I Medium	NC-710	Type II Medium	DC-100
Type I Firm	NC-711	Type II Firm	DC-113
MIL-T-6841	DK-153 or RK-304S	MIL-G-6747	DK-149

For additional data on the materials above, call your nearest Armstrong Industrial Division office or see Sweet's file for product designers.

New cork-and-rubber compounds. Armstrong's Research Laboratories are ready to develop new cork-and-rubber materials to meet new military requirements as they arise. Please discuss your needs with your nearest Armstrong representative . . . or write.

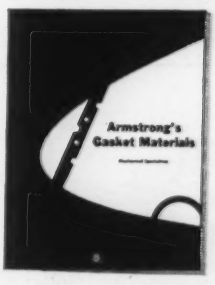
Cork compositions. There is an Armstrong Cork Composition made to meet each of the classes under Federal Specification HH-C-576, as well as each of the grades under specification MIL-C-16090.

Synthetic rubber compounds. Armstrong makes specialized synthetic rubber compounds for critical uses. Example: synthetic rubber valve washers for aircraft fuel and oil servicing nozzles made under MIL-N-4180.

Send for this gasket manual. It contains 24 pages of information designed to help you make the best use of Armstrong's Gasket Materials. Included are discussions of subjects such as designing gaskets to reduce cost . . . practical tolerances for resilient gaskets . . . designing gaskets for efficient sealing, and others.

You'll find, too, up-to-date data on cork-and-rubber, cork composition, and straight synthetic rubber gasketing materials. Included are current government specifications and tentative SAE-ASTM specifications.

See "Armstrong's Gasket Materials" in Sweet's file for product designers. For personal copy, write Armstrong Cork Company, Gaskets and Packings Department, 5111 Arch Street, Lancaster, Pennsylvania.



ARMSTRONG'S GASKET MATERIALS

Your nearest Armstrong Industrial Division office

ALBANY 10, N. Y., 64 Northern Boulevard, Telephone: 4-0131 • BOSTON 16, MASS., 131 Clarendon Street, Telephone: COpley 7-2490 • CHICAGO 54, ILL., 13-136 Merchandise Mart, Telephone: DElaware 7-0500 • CINCINNATI 2, OHIO, Temple Bar Building, 138 E. Court Street, Telephone: PArkway 3220 • CLEVELAND 15, OHIO, 209 Hanna Bldg. Annex, Prospect Ave. and E. 14th Street, Telephone: MAin 7900 • DETROIT 26, MICH., 10th Floor, Free Press Building, 321 Lafayette Avenue, West, Telephone: WOodward 3-5670 • GREENVILLE, S. C., 33 Norwood Place, Telephone: Greenville 3-5302 • LOS ANGELES 15, CALIF., 719 Bendix Building, 1206 Maple Avenue, Telephone: RICHmond 0286 • NEW YORK 16, N. Y., 295 Fifth Avenue, Telephone: MUrray Hill 4-6900 • PHILADELPHIA 2, PA., Robinson Building, Fifteenth and Chestnut Streets, Telephone: LOcust 4-4290 • ST. LOUIS 3, MO., 1205 Olive Street, Telephone: CHestnut 1757 • IN CANADA: Armstrong Cork Canada Limited, 6911 Decarie Boulevard, Montreal, Quebec, Telephone: ATlantic 4733.

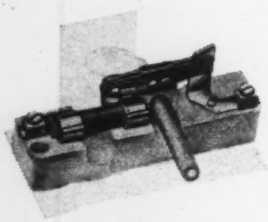
Safest...coolest!

THIS RADICALLY NEW Federal Noark Front-Operated Safety Switch is the coolest-operating switch available. It features guaranteed current break . . . visible blade construction . . . a special 3-position, front-operated handle . . . arc mufflers or Rolarc snuffers. Accommodation for four padlocks makes the switch practically tamper-proof.

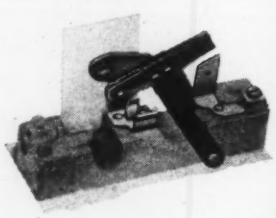
Type "A" Federal Noark Front-Operated Safety Switches come in 30, 60, and 100 ampere capacities for 230-volt A.C.—250-volt D.C., and for 575-volt A.C.—600-volt D.C. The Type "C" Front-Operated Safety Switches are made in the same sizes and ratings with many of the same advantages.

Order these superlative switches from your Federal Noark distributor. And write us today for free booklet.

Federal Electric Products Co., Newark 5, N. J.



COOLEST . . . The new Noark Safety Switch has only two joints to each pole, both under high tension.



SAFEST . . . This is the only visible blade switch with the operating cross bar beneath the switch blades.

Federal NOARK

FEDERAL NOARK

Plants at Newark, N. J.; Long Island City, N. Y.; Hartford, Conn.; St. Louis, Mo.; Los Angeles, Calif.

SALES AND SERVICE

Personnel

NEWLY appointed manager of induction motor sales of Redmond Co. Inc., **Gilbert Calkins** will make his headquarters at the main plant in Owosso, Mich. Mr. Calkins has served as a sales representative with John Oster Co., Racine, Wis., and the Norman H. Wright Co., Boston. He held the position of sales manager of the Electric Motor Corp. and with the Metal-Tex Corp., both of Racine. He joined the Redmond Co. in 1947 as a sales engineer, was appointed midwest area manager at Chicago, and has served as assistant sales manager until his latest appointment.

♦

Edward Burke has been named authorized sales representative in northern California for pneumatic products of C. A. Norgren Co., Denver. Having held executive sales positions with several California firms, Mr. Burke now heads The Burke Co. of San Francisco.

♦

Slater Electric and Mfg. Co. Inc., Woodside, Long Island, N. Y., manufacturer of wiring devices, has announced the appointment of **John C. J. Wirth** as vice president and sales manager.

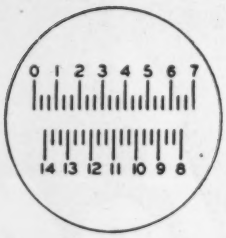
♦

Three new branch managers have been appointed by the Howe Scale Co., Rutland, Vt. **Lierd E. Grant** is now manager of the Los Angeles branch and will also continue to mange the San Francisco branch, where **William J. Tucey** has been appointed assistant branch manager. **O. B. Collins** and **Jack H. Brewer** have been named managers of the Atlanta, Ga., and Minneapolis branches, respectively.

♦

Allis-Chalmers Manufacturing Co. recently announced a number of personnel changes in its general machinery division. **C. W. Schweers**, director of sales, was elected vice president in charge of sales for the division. Having joined the company in 1930, he has served as manager of the general machinery district sales offices in Houston, Tex., and Los Angeles, and as manager of the New England region. Newly appointed district managers, **T. W. Metz** and **R. F. Loos** are now in charge of the Indianapolis and Evansville districts, respectively. **H. G. Crawford**, manager at Indianapolis since 1921, will

Work
There's a
Wallace
Barnes
Spring
to do it!
Bristol, Conn.



Custom-made Optical Reticles

...IN ANY DESIGN

Now Available in Quantity from

EXPANDED FACILITIES OF W. & L. E. GURLEY

Are you limiting your range and variety of reticle patterns to suit an available reticle-manufacturing process? You needn't at Gurley; here you can obtain the procedure best suited to your particular design and production requirements.

This century-old manufacturer of scientific instruments now offers for the first time on a contract-manufacturing basis its highly-developed photographic, microscopic ruling and etching facilities for producing *glass reticles* for all types of telescopes and optical measuring instruments.

Added to Gurley's extensive reticle-design and manufacturing facilities is an advanced photographic process developed during the war, to meet the low-tolerance specifications for reticles in gunsights and bombsights.

At Gurley you have the flexibility of several manufacturing processes and specially designed equipment to draw on—plus Gurley's long experience in optics, lens grinding and scientific instrument manufacture. Photograph and etch methods, direct ruling on a dividing engine or pantograph, as well as appropriate combinations of several of these methods, broaden the range of reticle pattern designs and assure their economical production in small or large runs.

Consult Gurley on your particular reticle needs —whatever the design or quantity.

W. & L. E. GURLEY, 201 Gurley Bldg., Troy, N.Y.

GURLEY

Optical Reticles, Engineering and Surveying Instruments, Hydraulic Engineering Instruments, Standard Precision Weights and Measures, Paper and Textile Testing Instruments, Aeronautical Navigating Instruments, Meteorological Instruments.

remain as a special representative. **W. F. Vander Mass** has been named manager of the Grand Rapids, Mich., district office, succeeding **George C. Culver,** who will serve as a representative in that area. **Walter W. Urmetz Jr.** has been named a sales representative in the Cleveland district office of the general machinery division.

♦

Warden F. Wilson has been elected president and general manager of Donegal Manufacturing Corp., Marietta, Pa. Formerly general sales manager of Lebanon Steel Foundry, Lebanon, Pa., he has been active for a number of years in the institution of research and product development activities. Donegal Manufacturing Corp. is a producer of carbon steel, low alloy and high alloy steel castings and also operates a nonferrous division. Currently the firm is undertaking a developmental and plant expansion program for manufacture of centrifugal cast jet engine components and other high-temperature service applications.

♦

Acro Manufacturing Co., Columbus, O., manufacturer of snap-action switches and temperature controls, recently added two new salesmen to its staff of field representatives. **Ralph McCort** has been assigned the territory comprising Michigan and northern Indiana, and **Al Unetic** will work out of the company headquarters in Columbus, serving Ohio and southern Indiana.

♦

The appointment of **Elmer Eugene Hightower** to its Detroit sales staff has been announced by the Lapeer Manufacturing Co., producer of toggle-action clamping devices.

♦

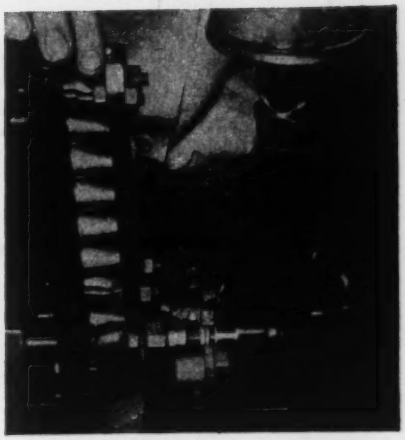
Manager of the Chicago sales office since 1931, **George C. Hochwalt** has been named sales manager of the S. Morgan Smith Co., York, Pa., manufacturer of hydraulic turbines, valves, pumps and allied equipment. Mr. Hochwalt has been associated with the company since 1920 and has served in various capacities in design, estimating, engineering and sales departments in the York office. He succeeds **Daniel J. McCormack,** who retired in August.

♦

John W. Belanger, of Schenectady, N. Y., and **Nicholas M. DuChemin,** of New York, have been elected vice presidents of the General Electric Co. Concurrently, Mr. Belanger was appointed general manager of the company's newly created Defense Products division. Mr. DuChemin was recently placed in charge of the Manu-

For Defense or Civilian use—get the mo$t for your Zinc Die Ca$ting Dollar!

Whether for defense or essential civilian products, design ZINC Die Castings *specifically* for this metal and method of production—to achieve maximum economy. The two ZINC Die Cast fuse noses for 20 mm. ammunition pictured above were designed to give Uncle Sam the most for his dollar. The same economic considerations apply to essential civilian castings.



MINIMIZE MACHINING

ZINC Die Castings are often produced so close to finished dimensions that little or no machining is required. In designing the fuse noses, however, it was less costly to cut the external threads than to cast them. Since the ZINC alloy is free-cutting, this operation is performed at high speed in a lathe fitted with an automatic feeding mechanism.

For a working knowledge of the full economic possibilities of ZINC Die Castings for defense or essential civilian products, ask us—or your die caster—for a copy of "Designing For Die Casting."

UTILIZE MULTIPLE PRODUCTION

Using a die designed to produce 12 fuse noses at a time, on a "gate" which is cast at the rate of 225 to 250 per hour, over 2700 noses are produced every 60 minutes in a plunger-type die casting machine. Of the most used die casting metals, only ZINC alloys can be used in these high speed machines.

DON'T WASTE METAL

All excess metal is sheared off when the 12 castings are removed from the gate simultaneously in a punch press. Thus all of the flash metal, as well as the gate, is salvaged for remelting and reuse. This not only minimizes metal cost but conserves zinc which is so essential to the National Defense program.

The New Jersey Zinc Company, 160 Front St., New York 38, N. Y.

ZINC
FOR DIE CASTING ALLOYS

The Research was done, the Alloys were developed, and most Die Castings are based on
HORSE HEAD SPECIAL (99.99+% Uniform Quality) ZINC

There is a solution to the problem of undesirable vibration —LORD Bonded-Rubber Mountings. The result . . . improved product performance in many ways. LORD Mountings make mechanical equipment smoother . . . quieter . . . easier to operate . . . easier to sell. They protect precision and accuracy . . . increase personnel efficiency and production . . . prolong service life and reduce maintenance costs . . . save vital material . . . cut scrap loss.

LORD Mountings have been found indispensable for hundreds of modern products. They offer many advantages for the simplification of design, reduction of weight, speedier and more economical assembly, and greater operating efficiency.

To attain these performance improvements, vibration-control should be planned as an integral part of your product. LORD Engineers will assist you to most effectively adapt flexible mountings to your designs . . . select mountings of proper type, size, and deflection . . . position the mountings for greatest effectiveness.

Whether you make sensitive instruments or massive machinery, it will be to your advantage to make LORD Vibration-Control part of design. For improved product sales appeal, bring your vibration problems to LORD . . . Headquarters for Vibration-Control.

LORD MANUFACTURING COMPANY, ERIE, PA.

LORD BONDED RUBBER

Vibration-Control Mountings . . . Bonded-Rubber Parts

facturing Services division. Both of these men have been associated with General Electric for over 30 years. The company also recently announced the appointment of **Arthur F. Vinson** as assistant manager of the Manufacturing Services division. Formerly manager of employee and community relations of the Small Apparatus division at Lynn, Mass., he will now be located in Schenectady.

♦

E. J. Campbell has been appointed midwestern district sales manager of Wolverine Tube division of Calumet and Hecla Consolidated Copper Co., Detroit. Mr. Campbell has been affiliated with the company since 1943 and has worked closely with both the inside and outside sales staffs. He will continue to make his headquarters in the Chicago offices and will supervise sales activities throughout twelve midwestern states.

♦

Formerly sales manager, **James F. Murphy** has been appointed vice president in charge of sales of the Howell Electric Motors Co., Howell, Mich.

♦

With headquarters in the company's Passaic, N. J., plant, **Wenzel A. Lindfors** has been appointed sales manager of the New York Belting and Packing Co. to direct all sales for the company's line of industrial rubber products such as transmission, conveyor and elevator belting, water, air and gasoline hose, packings, molded and extruded goods. He formerly served as factory representatives for the company in Minnesota, northern Wisconsin, North and South Dakota and northern Iowa.

♦

The Timken Roller Bearing Co., Canton, O., has announced the appointment of **George T. Humphrey Jr.** to the post of assistant general manager of the service sales division. He leaves his post as assistant branch manager of the service sales division of Dallas, Tex., to assume his new duties.

♦

General sales manager of the Naugatuck Chemical division, United States Rubber Co., **George R. Vila** has been honored by the U. S. Army for his services with the Technical Industrial Intelligence Committee of the Joint Chiefs of Staff during World War II. Mr. Vila received a certificate of appreciation for his work as a member of a group of six rubber scientists who investigated the research phases of the German synthetic rubber industry in 1945. The findings of this committee led to the

We specialize in the production of sleeve bearings and parts with bearing properties.

Within our six-plant manufacturing organization, our products range from simple spacer tubes to big, precision bearings weighing hundreds of pounds each. We work with babbitt, copper-lead, bronze, steel, brass, aluminum or silver—in standard or special alloys to meet exact specifications.

All production rigidly quality-controlled. Research and engineering facilities available without obligation. **FEDERAL-MOGUL CORPORATION, 11045 Shoemaker, DETROIT 13, MICHIGAN**

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SAVE ON PARTS AND MATERIALS

THIS FREE DISSTON BOOK TELLS YOU HOW!

This new Disston guide—sent FREE on request—is a "must" reference book for every production-minded cost-conscious engineer, designer, and purchasing man. In 16 fact-packed illustrated pages it gives you the story of Disston Custom Steel Parts: what they are; how they are made; typical products; how to order. And, of prime importance, this book blue-prints the facilities of the Disston Custom Parts Plant for handling intricate designs, exacting tolerances, and special heat treating . . . to individual specifications. We'll gladly send your copy on request —write on your letterhead or use the coupon.

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development of cold GR-S synthetic rubber in this country, as well as many other improvements in the quality and versatility of synthetic rubber.

♦

With a broad background of experience as an industrial engineer in the field of mechanical rubber products, **L. R. Ervin** has been appointed manager of the Cleveland branch and sales office of The Ohio Rubber Co., Willoughby, O. Mr. Ervin will provide consultation, engineering and sales service to customers in the Cleveland area.

♦

H. E. Chilcoat is now assistant general sales manager of the Townsend Co., New Brighton, Pa., manufacturer of large and small solid rivets, tubular rivets, blind rivets, self-tapping screws and other cold headed fasteners and parts.

♦

Manufacturer of flexible hose lines and self-sealing couplings for industrial and aircraft application, Aeroquip Corp. has appointed **William Rowley** as manager of its new office located in the Monument Bldg., Dayton, O. Mr. Rowley has been a staff engineer for the company since 1948 and previously was associated with the Ranger Aircraft Corp., Glenn L. Martin Co. and Pitcairn Autogyro Corp.

♦

Malvern J. Hiler has been appointed president of The Commonwealth Engineering Co. of Ohio. For the last three years he has served as executive vice president.

♦

General sales manager of Ampco Metal Inc., Milwaukee, **S. C. Lawson** was appointed by the board of trustees of the American Society for Metals as one of the American conferees at the World Metallurgical Congress held in Detroit, October 14 through 19.

♦

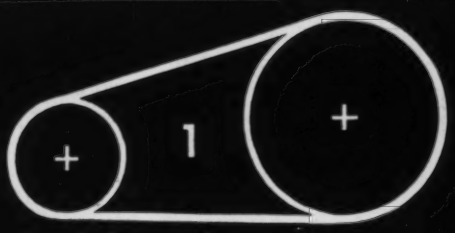
J. B. Laramy has been appointed manager of the marketing research department of Worthington Pump and Machinery Corp., Harrison, N. J. He has been assistant manager of the Chicago district office for the past six years and is replaced in that position by **J. T. Carroll**, who had been regional distributor supervisor of the air conditioning and refrigeration division at Chicago.

♦

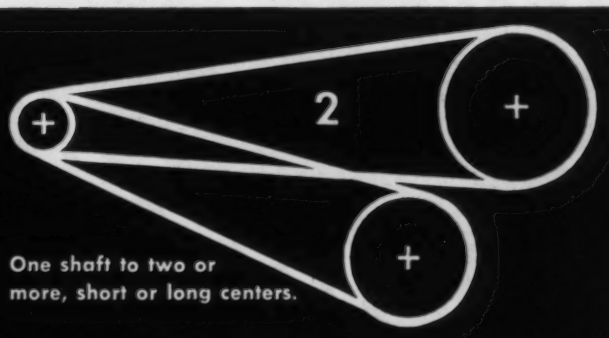
The Geneva Metal Wheel Co., Geneva, O., recently announced that **H. Albert Ford** has been elected vice president and sales manager.

DIAMOND ROLLER CHAINS

Simplify Power Transfer



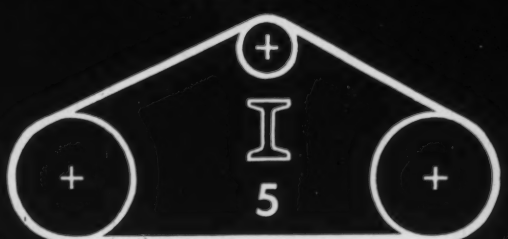
One shaft to another—no slip or creep.



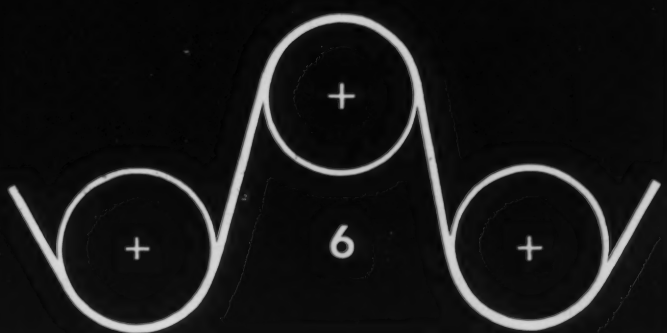
One shaft to two or more, short or long centers.

To drive from A to B with gears in same direction — extra shaft and gear (C) needed—extra weight.

With Diamond, drive from A to B is simple.



No trouble getting around an obstruction.



Driving a series of shafts with Diamond offers unusual flexibility.

REDUCE COSTS AND WEIGHT, FACILITATE ASSEMBLY

● The few examples outlined above show the flexibility of Diamond Roller Chain application—and how simplification is attained.

Assembly and disassembly are simple—drives from one shaft to another or to several other shafts present no problem. Compare drawings (3) and (4) above. To rotate two shafts in the same direction by gears requires a third gear and shaft, while the Diamond Chain as in (4) does the job whether the center distances are short or long and regardless of the speed ratio. And there is no slippage.

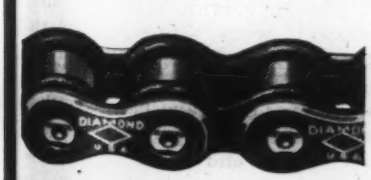
In (5) the ease of getting around an obstruction is illustrated and (6) shows how a series of shafts can be positively rotated with sprockets of various sizes to provide the speed of rotation desired.

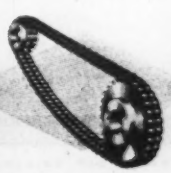
Diamond Roller Chains do these jobs and many others with long-life, low-cost dependability, for every link is precision made by workmen skilled in chain making for over 60 years.

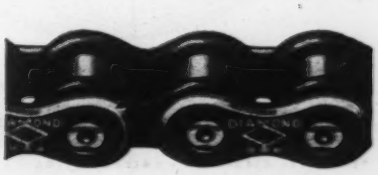
DIAMOND CHAIN COMPANY, Inc.

Dept. 435, 402 Kentucky Avenue **Indianapolis 7, Indiana**

Offices and Distributors in All Principal Cities



DIAMOND  **ROLLER CHAINS**



Should you put *your* horsepower to work through some type of *friction clutch*—or some type of *hydraulic drive?* Or a *combination* of both.

Which will make your equipment operate *most efficiently,* at *less cost?* That's one of the tough problems operating men and design men must face today.

And there is only one sure way to find the right answer.

That's to work with application engineers like those you find at the Twin Disc Clutch Company. Men who are trained in applying *all* types of friction clutches and *all* types of industrial fluid drives. Men who are trained to give you an *impartial* recommendation... because no matter what the honest answer may be they can supply the type of connecting link *you should have.*

Yes, for the answer to *your* "which," consult the men who base their answers on the most complete line of industrial clutches and hydraulic drives ... and on the extensive experience of *specialization* for over 30 years.

TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES

Clutches & Hydraulic Drives

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin • HYDRAULIC DIVISION, Rockford, Illinois

BRANCHES: CLEVELAND • DALLAS • DETROIT • LOS ANGELES • NEWARK • NEW ORLEANS • SEATTLE • TULSA

SALES Notes

FORMERLY established at the plant, the local district sales headquarters of **The Babcock & Wilcox Tube Co.,** Beaver Falls, Pa., have been moved to a new office building in the business section of the city. Located at 712 Eleventh St., the new office handles the sales of seamless and welded stainless, alloy and carbon steel tubing in western Pennsylvania, western New York, Ohio, southern Indiana, and the states of Kentucky, West Virgiina, Tennessee, North and South Carolina, Georgia, Alabama, Florida and parts of Canada. A suboffice in Cleveland and a sales representative in Toronto, Ontario, Canada, help serve this territory.

♦

Columbia Electric Supply Co. Inc., Washington, D. C., has been named a distributor for **Allis-Chalmers Manufacturing Co.** motors in the District of Columbia, Prince Georges, Calvert and Montgomery counties in Maryland, and in Fairfax and Arlington counties in Virginia.

♦

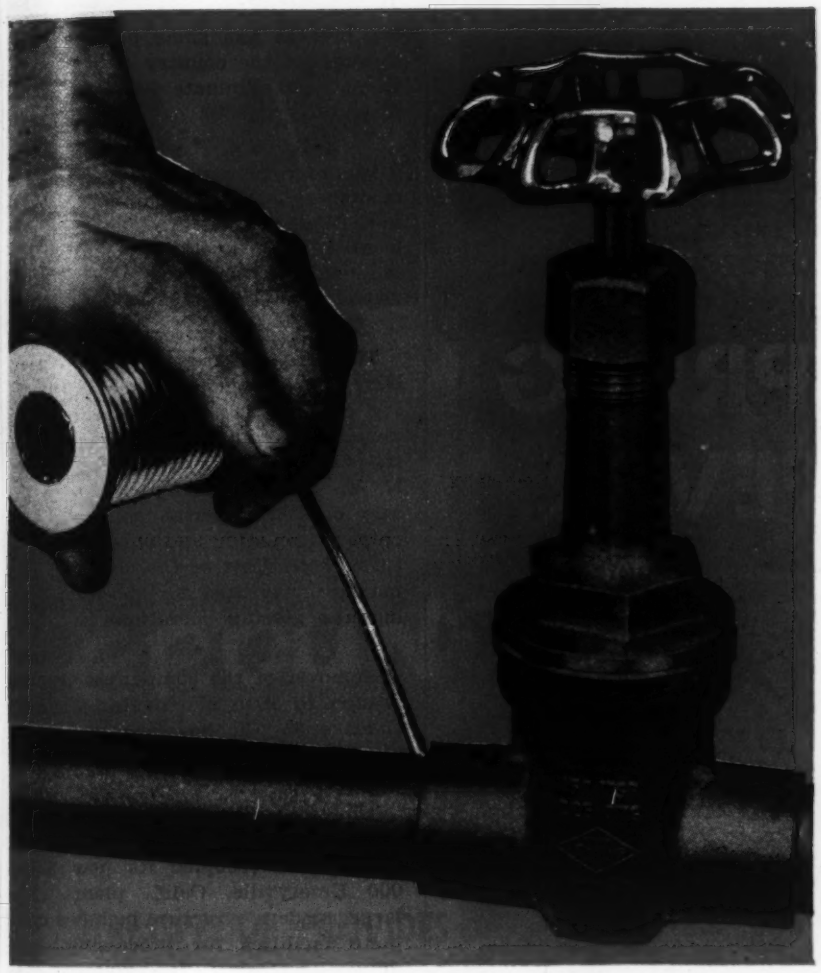
Opening of a Chicago division to provide a consulting service on a national scale for the application of notched-coil silver brazing and soldering rings and coined washers for armament production has been announced by **Lucas-Milhaupt Engineering Co.,** Cudahy, Wis. The division will be directed by Harlan Olson, who has served as chief consulting and application engineer for the company since April.

♦

The Milwaukee district sales office of **Chain Belt Co.** has been moved to 4532 West Greenfield Ave. The company has also recently announced the appointment of the **Cate Equipment Co.,** 49 East Ninth South, Salt Lake City, as its new district sales office in the Salt Lake City area.

♦

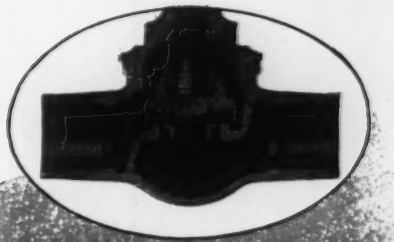
A method of completely eliminating porosity in metal alloy castings and fiberglass laminates is now available on a custom service basis in thirty industrial areas throughout the United States and Canada. Originally developed by **Western Sealant Inc.,** Culver City, Calif., and used by West Coast manufacturers of aircraft, hydraulic, pump and radar equipment.



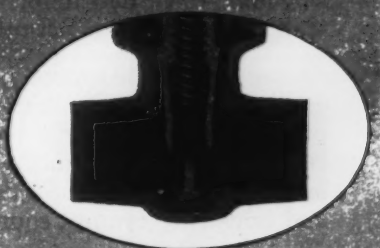
For

EASY INSTALLATION
POSITIVE CONTROL
LASTING ECONOMY
in copper line service

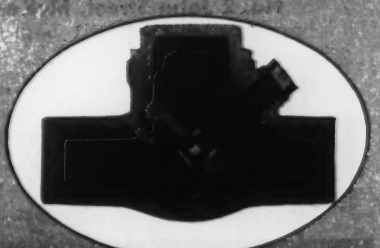
JENKINS *Solder-End* VALVES



GLOBES 300 lbs. O.W.G. ¼" to 3" Fitted with Jenkins Renewable Composition Disc for any specified service.



GATES 225 lbs. and 300 lbs. O.W.G. ¼" to 3" With solid or split wedges, and stationary or traveling spindles.



CHECK 300 lbs. O.W.G. ¼" to 3" Regrinding. May be easily reground without removal from line.

To speed installation in copper lines, you want a valve with an accurate fit to tubing—a valve that will not distort under the intense heat of soldering. And, because flexible tubing does not afford the rigid support of standard pipe, you want a valve that will withstand unusual strains in operation.

To give you Solder End Valves that meet *every* test in the toughest service Jenkins valve specialists designed them with an extra measure of rugged endurance, along with the dimensional accuracy and operating efficiency you expect in all valves of Jenkins quality.

A new Folder, Form 198, describes the complete line of Jenkins Solder End Valves, shows construction details, and gives instructions for correct installation. Get your copy—see why so many economy-wise valve buyers specify *Jenkins*. Jenkins Bros., 100 Park Ave., New York 17. Jenkins Bros., Ltd., Montreal.

GET THIS New FOLDER ON JENKINS Solder End VALVES

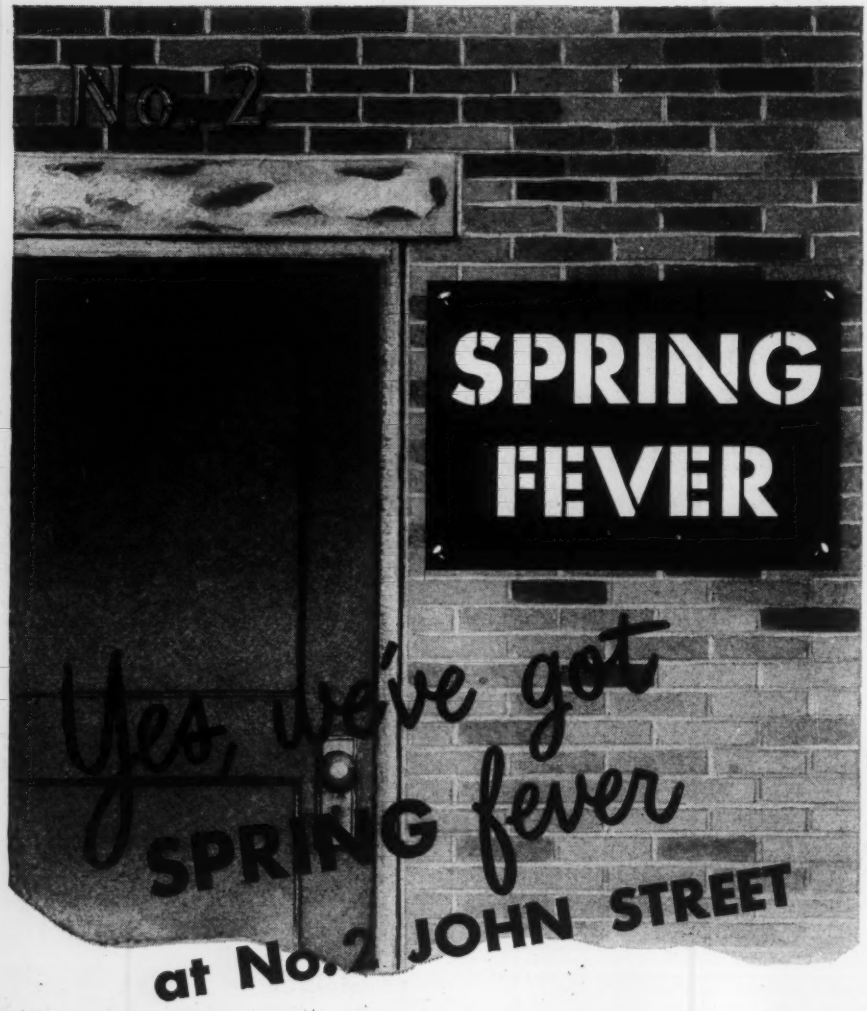
Gives complete description, dimensions and instructions for installation. See your Jenkins Distributor or write for Form 198. Jenkins Bros., New York 17.

JENKINS VALVES

LOOK FOR THE DIAMOND MARK

TRADE JENKINS MARK

Jenkins Bros



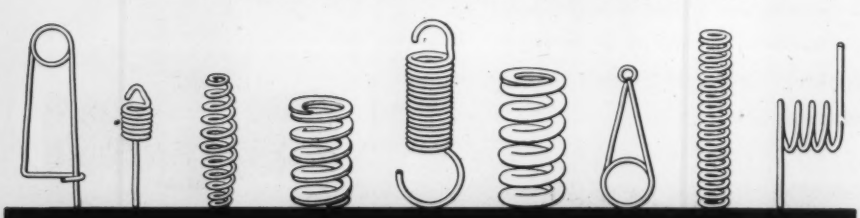
. . . and we've had it for more than 60 years . . . a burning ambition to make constantly better springs.

As long-time specialists in hot or cold wound springs, our engineers are often instrumental in helping people like yourself improve product performance and reduce production costs. Our old customers (and we hope you will become one) have learned to look to No. 2 John Street as a thoroughly reliable and unusually prompt source of supply.

AMERICAN-FORT PITT SPRING DIVISION

H. K. Porter Company, Inc.

No. 2 John Street, McKees Rocks, Pa. (Pittsburgh District)



AMERICAN-FORT PITT

SPRINGS

the process has since been adopted throughout the country as a production step to eliminate delivery lag due to porosity rejects.

♦

In order to expand its service to customers in Michigan, **Pratt & Whitney**, West Hartford, Conn., has relocated its Detroit office in a new building at 8626 West McNichols Rd., Detroit 21, Mich.

♦

The Lea Manufacturing Co., Waterbury, Conn., manufacturer of finishing compositions and equipment, has announced a selling agreement with the **Clair Manufacturing Co.**, Olean, N. Y., whereby Lea will handle the sale of Clair special polishing machinery to plating and finishing plants throughout most of the country. This machinery is used for special polishing and glazing operations.

♦

Removal of the company's Chicago branch to 1915 North Harlem Ave., Chicago 35, Ill., has been announced by **The Howe Scale Co.**, Rutland, Vt.

♦

The Clearprint Paper Co., producer of technical drawing and tracing papers, has occupied its new $250,000 Emeryville, Calif., plant. The large, modern structure includes complete facilities for processing, handling and storing Clearprint paper.

♦

Manufacturer of stainless, low-alloy, high-tensile, and nonferrous electrodes, **Arcos Corp.**, Philadelphia, has appointed two new exclusive distributors. **The Clements Welding & Machinery Co.**, 700 Hawk Ave., St. Louis 10, Mo., will service the St. Louis area and southern Illinois east of Springfield and Sedalia, and **The R. & R. Welding Supply Co.**, 315 Twelfth St., Des Moines, Ia., will cover central Iowa, including Cedar Rapids, Mason City, Waterloo and Fort Dodge.

♦

Tipaloy Inc., Detroit, has appointed **Weldit Inc.**, 990 Oakman Blvd., Detroit 6, Mich., as national distributor for Tipaloy resistance welding electrodes.

♦

Hanna Engineering Works, Chicago, has appointed **Sweetland-Affleck Corp.** as exclusive dealer for central and southern California, to handle pneumatic and hydraulic cylinders and control valves. The Sweetland-Affleck office at 940 North Fair Oaks, Pasadena, will handle all of California south of Fresno, while the central part of the state will be covered from the office at 405 Montgomery St., San Francisco.

SAVE SHOP LABOR SHOP TIME GRINDING COSTS

GROUND and POLISHED

STRESSPROOF PROVIDES 4 QUALITIES IN 1 BAR

1. Eliminates Heat Treating

Its *in-the-bar* strength, as received, is twice as great as ordinary cold-finished steel shafting.

2. Eliminates Case Hardening

Its resistance to wear, as machined, is sufficient to replace many heat-treated or carburized steels.

3. Minimizes Warpage

Because it is *stress-relieved*, this superior bar assures the user a minimum of distortion.

4. Speeds Up Machining

Has *in-the-bar* machinability fully 50% better than heat-treated alloys of the same hardness.

Many companies are realizing important savings by using Ground and Polished STRESSPROOF bars instead of grinding the steel in their own shop. For this superior steel provides precision tolerances at a reasonable cost, without tying up valuable labor and machinery.

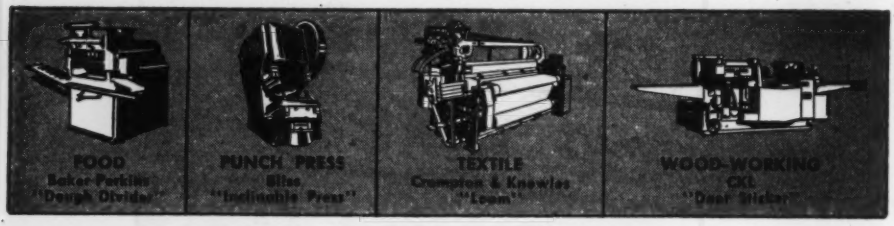
This all-purpose bar stock is ground to close tolerance and highly polished at the LaSalle plant on batteries of modern machines — at lower cost than you can grind it yourself. Furthermore, because this versatile steel is stress-relieved, it requires no straightening after keyseating, journaling, threading, or other machining operations. And its four qualities in-the-bar eliminate many other costly operations.

Almost all of today's Ground and Polished STRESSPROOF production is going into defense jobs. However, from time to time, some sizes of sample bars may be available for testing purposes.

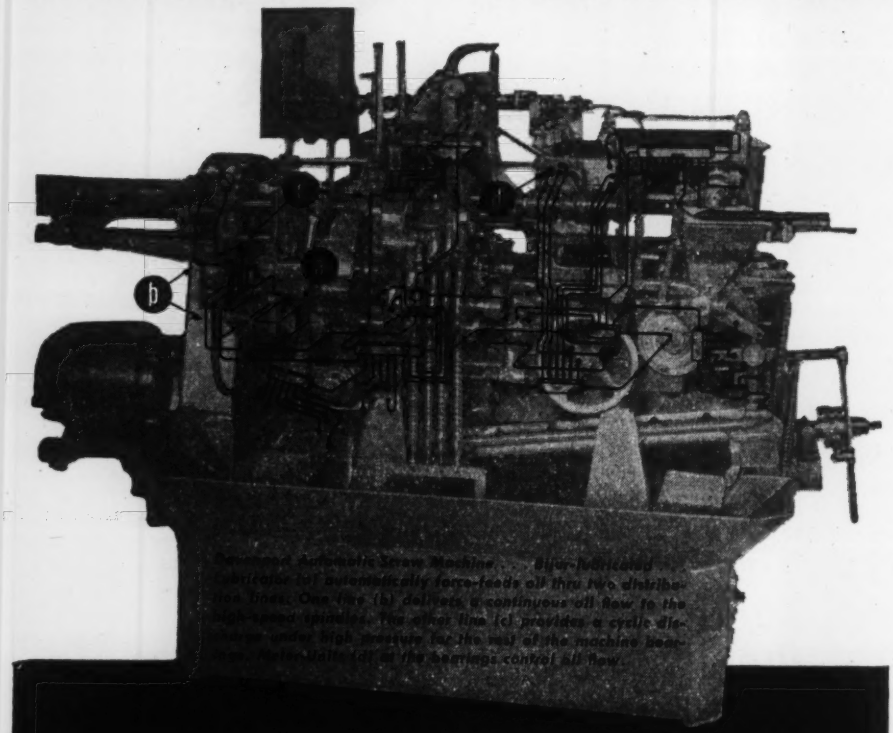
LaSalle STEEL CO.

1426 150th Street, Hammond, Indiana

LEADING MANUFACTURERS BUILD IN THE BIJUR SYSTEM



automatic lubrication



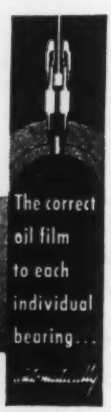
boosts production and cuts maintenance

Designing an automatic lubricating system into a machine doubles your prospects for user satisfaction.

First, maintenance time is converted into more time for production. A Bijur-lubricated machine oils itself during operation, doing away with wasteful down-time for lubrication.

Next, maintenance costs are cut as effective bearing life is lengthened. The Bijur system provides positive Meter-Unit control of oil flow *at the bearings*, considerably reducing bearing wear.

When you design that new machine, call on the Bijur engineer. Meanwhile, for further information write for "The Travels of Modern Lubrication."



389

BIJUR LUBRICATING CORPORATION

ROCHELLE PARK, NEW JERSEY

Meetings

AND EXPOSITIONS

Nov. 14-16—

American Institute of Electrical Engineers. Fourth annual machine tool-industry conference sponsored by Machine Tool Subcommittee of Committee on General Industry Applications to be held at the Faust Hotel, Rockford, Ill. H. H. Henline, 33 West 39th St., New York 18, N. Y. is secretary.

Nov. 14-17—

Society of Naval Architects and Marine Engineers. Fifty-ninth annual meeting to be held at the Waldorf-Astoria in New York, N. Y. Additional information may be obtained from society headquarters, 29 West 39th St., New York 18, N. Y.

Nov. 15-16—

Magnesium Association. Seventh annual meeting to be held at the Biltmore Hotel, New York, N. Y. Additional information may be obtained from society headquarters, 122 East 42nd St., New York 17, N. Y.

Nov. 19-20—

National Metal Trades Association. Fifty-second annual convention to be held at the Palmer House, Chicago, Ill. Additional information may be obtained from Society headquarters, 122 S. Michigan Ave., Chicago 3, Ill.

Nov. 25-30—

American Society of Mechanical Engineers. Annual meeting to be held at the Chalfonte-Haddon Hall, Atlantic City, N. J. C. E. Davies, 29 W. 39th St., New York, N. Y. is secretary.

Nov. 26-Dec. 1—

Exposition of Chemical Industries. Twenty-third exposition to be held in Grand Central Palace, New York, N. Y. Charles F. Roth, Grand Central Palace, 480 Lexington Ave., New York 17, N. Y. is manager.

Nov. 28-30—

Society for Experimental Stress Analysis. Annual meeting and exhibit to be held at the Bellevue-Stratford Hotel, Philadelphia, Pa. W. M. Murray, P. O. Box 168, Cambridge 39, Mass., is secretary-treasurer.

Nov. 30

Malleable Founders' Society. Western sectional meeting to be held at

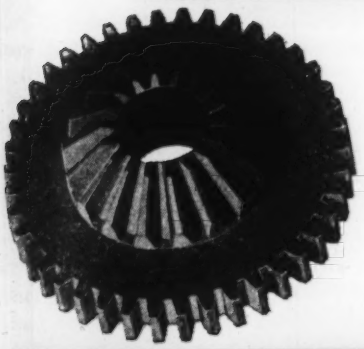
In Powder Metal they cost 80% less!

Products of Powdered Metal Products Corporation of America, Franklin Park, Illinois, specialists in gear making.

Bevel gear for power drill

Each of these gears is prohibitively expensive to make by conventional machining operations. In powder metal, each is formed at a single stroke.

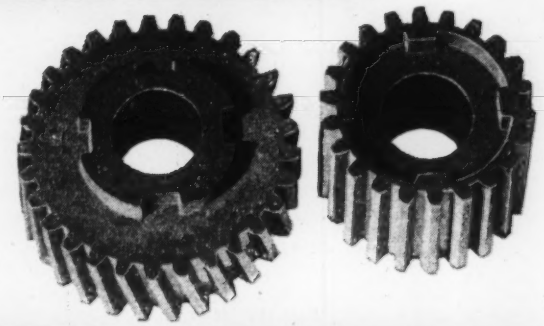
The small bevel gear for a power drill has a tensile strength of 100,000 psi. Savings in powder metal: 8 machine operations, 86% of total cost.



Spur and mitre gear for business machine

The mitre gear is used in a business machine. Savings in powder metal: 15 machining and assembly operations, 80% of total cost.

The helical and spur gear are used in an automatic washing machine transmission. Savings in powder metal: 18 machining and assembly operations, 88% of total cost.



Helical and spur gears for transmission in washing machine

To these and many other parts difficult or costly to form, powder metal processing is rapidly extending its many economies. Consult Stokes, makers of powder metal presses, on powder metal possibilities. Send parts or blueprints for report by Stokes engineers on their adaptability to powder metal processing.

A comprehensive booklet "Powder Metallurgy Today" will be sent on request.

STOKES

STOKES MAKES

Plastics Molding Presses,

Industrial Tabletting

and Powder Metal Presses,

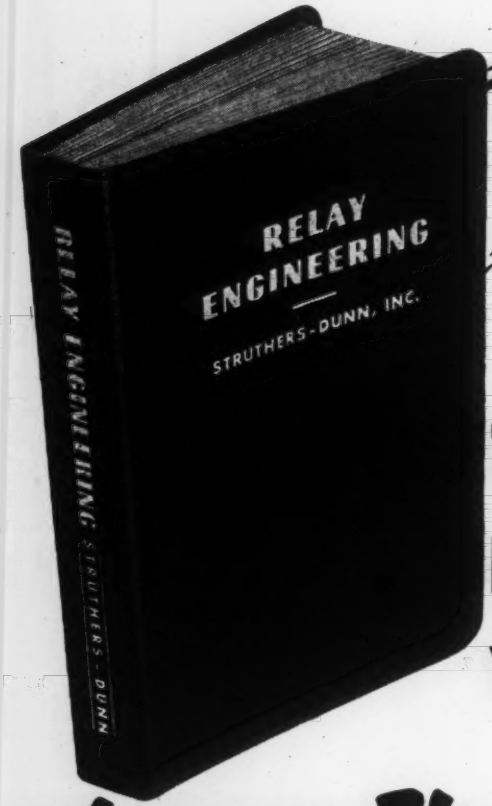
Pharmaceutical Equipment,

Vacuum Processing Equipment,

High Vacuum Pumps and Gages,

Special Machinery

F. J. STOKES MACHINE COMPANY, 5556 TABOR ROAD, PHILADELPHIA 20, PA.



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This famous 640-page Struthers-Dunn RELAY ENGINEERING HANDBOOK answers your questions about relays—explains fundamental types—tells what types to use for specific applications—serves as a comprehensive guide to relay circuits, relay selection, application, use and maintenance. Contains over 1100 illustrations. Limp bound in convenient pocket size. *Price $3 per copy.*

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the Drake Hotel, Chicago, Ill. Additional information may be obtained from society headquarters, 1800 Union Commerce Bldg., Cleveland, O.

Dec. 2-5—

American Society of Refrigerating Engineers. Forty-seventh annual meeting to be held at the Hotel Roosevelt, New Orleans, La. Additional information may be obtained from society headquarters, 40 West 40th St., New York 18, N. Y.

Dec. 5-6—

National Warm Air Heating and Air Conditioning Association. Thirty-eighth annual convention to be held at Hotel Cleveland, Cleveland, O. George Boeddener, 145 Public Sq., Cleveland 14, O., is managing director.

Dec. 6-8—

American Institute of Mining and Metallurgical Engineers. Electric furnace steel conference to be held at Hotel William Penn, Pittsburgh, Pa. Additional information may be obtained from society headquarters, 29 West 39th St., New York 18, N. Y.

Dec. 17-19—

American Society of Agricultural Engineers. Winter meeting to be held at the Stevens Hotel, Chicago, Ill. Raymond Olney, P. O. Box 229, St. Joseph, Mich., is secretary.

Jan. 14-17—

Plant Maintenance Conference. Third conference to be held concurrently with the Plant Maintenance Show at Convention Hall, Philadelphia, Pa. Additional information may be obtained from the exposition management, Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

Jan. 14-18—

Society of Automotive Engineers. Annual meeting to be held at Hotel Book-Cadillac, Detroit, Mich. John A. C. Warner, 29 West 39th St., New York 18, N. Y., is secretary and general manager.

Jan. 16-18—

Society of Plastics Engineers. Eighth annual national technical conference sponsored by the Chicago section of the SPE to be held at the Edgewater Beach Hotel, Chicago, Ill. Mrs. Bess R. Day, 409 Security Bank Bldg., Athens, O., is executive secretary.

PRODUCT DESIGN STUDIES • NO. 33

Fabricated KING PIN

Cast Steel KING PIN

Weight Reduced 23%
Faster Production
High Strength
with STEEL CASTINGS

This king pin — pivot between the power unit and scraper of a heavy-duty, self-propelled, earth-moving machine — was formerly produced as a forging-weldment combination.

Conversion to a steel casting reduced the weight from 1100 lbs. to 850 lbs., provided strength equal to the strength of the more massive forging, and reduced production time by eliminating more than forty hours of welding.

* * *

Here is another example of the engineering teamwork in design and redesign of parts which is resulting in greater serviceability and lower costs with steel castings.

This service is offered without cost or obligation. It makes available through your foundry engineer the full results of the development and research program carried on by the Steel Founders' Society of America.

An Urgent Message About *Scrap*...

There is a serious shortage of iron and steel scrap. Your company can help insure the continued high production of all metal products by getting your scrap into the hands of your scrap dealer. Will you do what you can to help...*now*?

STEEL FOUNDERS' SOCIETY OF AMERICA

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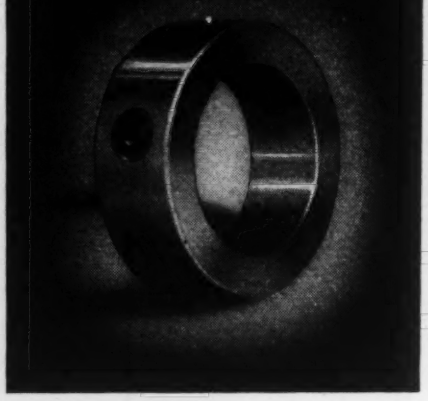
Design and Build With Steel Castings

HALLOWELL®

SOLID STEEL COLLARS
with
UNBRAKO
Self-Locking
HOLLOW SET SCREWS



Used Profitably...

by manufacturers of such widely diversified products as *lawn mowers, food machinery, textile machinery, juke boxes, snow plows, conveyors, air compressors, agricultural machinery, electric fans, bottling machines,* and dozens of others.

Precision machined from solid bar stock in 42 stock sizes for shafts from 3/16″ to 3″ diameters inclusive.

Write for prices and name of your nearest distributor.

—SPS—

STANDARD PRESSED STEEL CO.
JENKINTOWN 18, PENNSYLVANIA

New Machines

Heating and Ventilating

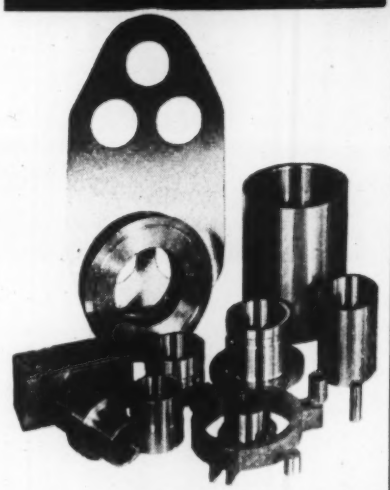
AIR CONDITIONERS: Five sizes with capacities ranging from 12 to 58 tons. Provide independent control in separate areas of a building through single unit. Number of zones possible with factory-built damper section varies from five for smallest size to 14 for largest. Intermediate sizes include seven and ten-zone units. Horizontal blowthrough type. Damper control for separate zones provided through double outlet arrangement, with one outlet supplying cooled and dehumidified air and the other supplying warm air. Twin outlets are divided into separate dampering compartments. Independently operated double damper in each compartment regulates proportion of warm and cool air for the zone, shutting down on the supply of one as the other is increased. *Carrier Corp., Syracuse, N. Y.*

Manufacturing Equipment

CENTRIFUGAL CASTING MACHINE: Model R faceplate type unit for production of large-diameter, relatively short-length castings. Molds up to 25,000 lb and 40 in. long can be accommodated for making castings up to 6 ft in diameter. Features water-cooled shaft and bearings. *The Centrifugal Casting Machine Co., Tulsa, Okla.*

OVERLOAD PRESS JACK: Hydraulic unit can be fastened directly to bolster plate or press bed frame. Hydropneumatic pump operates directly off average shop air line. Control valve can be set at any desired tonnage, thus giving desired overload protection to press and to tools being used. Can be used in riveting, marking, stenciling, squeezing, assembling, forming, swaging and staking operations. Made in eight sizes, up to and including a maximum of 200-ton capacity. *Dayton Rogers Manufacturing Co., Minneapolis, Minn.*

ROUTER-SKIN MILL: Automatic, electronic-controlled power feed Invo-Mill for production of aircraft parts. Permits routing of thicker stocks of aluminum and other nonferrous metals than heretofore possible with standard hand-feed routers. Used in making grids to hold gas tanks and other parts inside air-



American Crucible methods, experience, know-how and equipment result in highest quality. . . . . .bearings that carry a

MONEY-BACK GUARANTEE OF LONGER SERVICE AND LOWER MAINTENANCE COST

PROMET
THE Engineered BRONZE

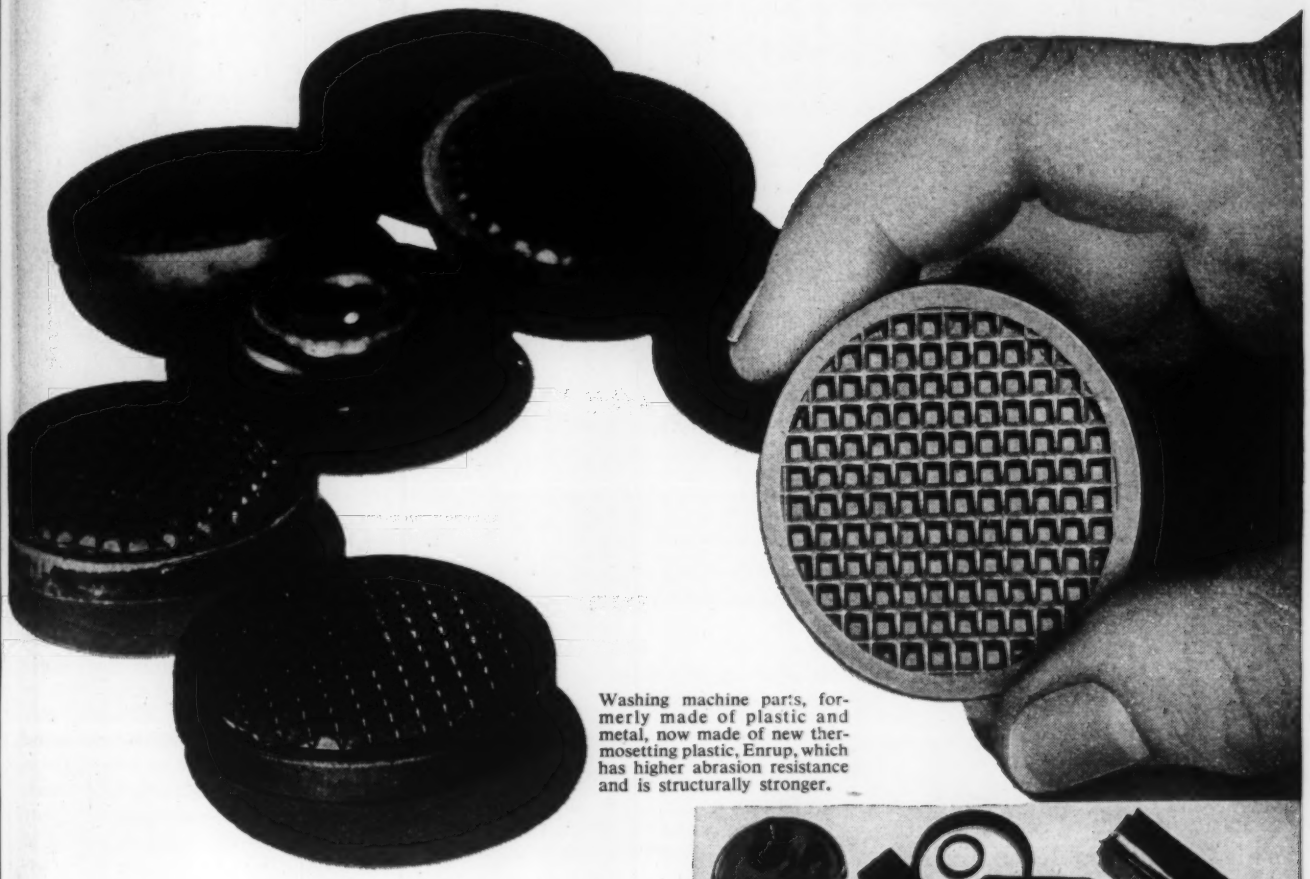
BEARINGS ● BUSHINGS
WEARING PARTS

Machined or Rough Cast of the Specific Formula Best Suited to the Application.

Write for literature or send blueprints, conditions of operation, etc. for quotations and recommendations as to alloys.

THE AMERICAN CRUCIBLE PRODUCTS CO.
1321 Oberlin Ave., Lorain, Ohio, U. S. A.

What's U. S. Rubber doing to bridge the gap between hard and soft rubber?

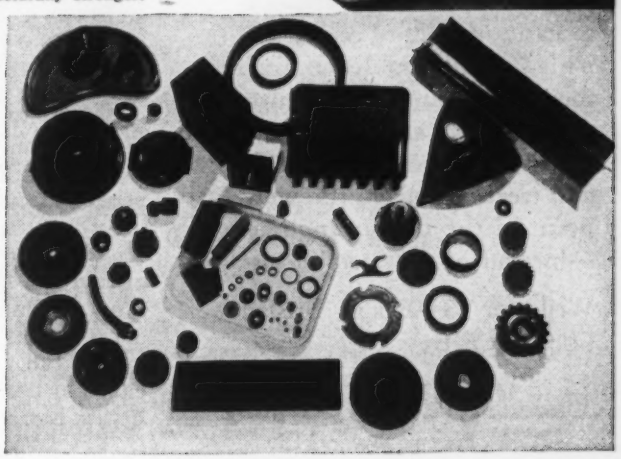


Washing machine parts, formerly made of plastic and metal, now made of new thermosetting plastic, Enrup, which has higher abrasion resistance and is structurally stronger.

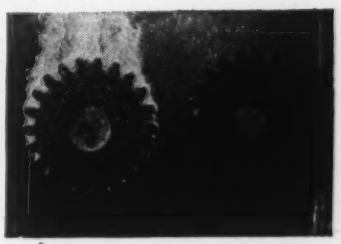
The new "U.S." thermosetting plastic, Enrup, can be made flexible and elastic as soft rubber, or rigid as hard rubber. Enrup offers entirely new possibilities to design engineers. The washing machine parts, shown above, are made of Enrup because its abrasion resistance and structural strength are greater than the combination of metal and plastic formerly used.

Enrup can be made into almost any shape or form, simple or complex. It can be punched, sanded, sawed, nailed, bolted, molded and machined. Perhaps Enrup is just what you've been looking for to improve your product or your manufacturing operation.

For more details, write to address below.



Some of the products made of Enrup for leading manufacturers. The smallest items weigh as little as one-third of an ounce. Engineers often find Enrup cuts molding costs, permits operating economies hitherto impossible.



Note how a bath of 20 percent solution of sulphuric acid eats away the steel gear at left, while the Enrup gear is unharmed. Enrup is non-conductive, non-absorbent, easy to clean, is noiseless.

PRODUCT OF

U.S.RUBBER
SERVING THROUGH SCIENCE

UNITED STATES RUBBER COMPANY

MECHANICAL GOODS DIVISION • ROCKEFELLER CENTER, NEW YORK 20, N. Y.

craft wings. A 30-hp motor supplies power for routing aluminum stock 1 in. or more thick; 40-hp, 5400 rpm direct-driven, liquid-cooled motor mounted on cross rail provides power for milling. Table widths of 72, 84 and 96 in. available with bed lengths in multiples of 15-ft sections plus 7-ft for conveyor. *Onsrud Machine Works Inc., Chicago, Ill.*

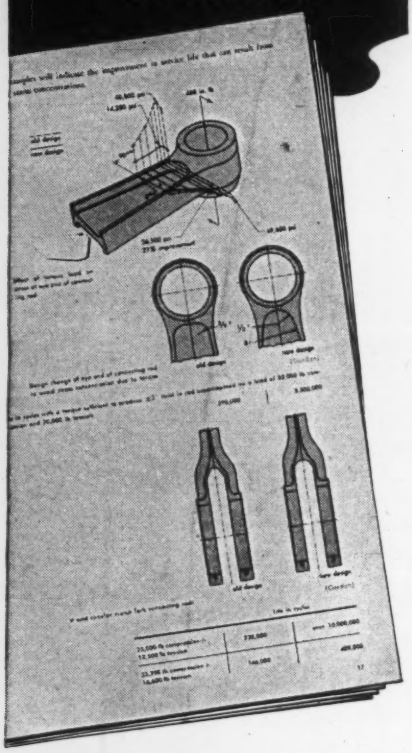
PORTABLE ELECTRIC DRILLS: Available in ¼, ⅜ and ½-in. capacities. Features include aluminum bodies, heat-treated alloy steel gears; forced ventilation for coolest operation at peak power in continuous use. Standard, heavy and extra-heavy duty models offered in ¼-in. capacity in eight speeds, 500 to 5000 rpm, no load; heavy and extra-heavy duty in ⅜-in. capacity in no-load speeds from 400 to 1000 rpm; and standard, heavy and extra-heavy duty in ½-in. capacity, 500 to 600 rpm. *Portable Electric Tools Inc., Chicago, Ill.*

TAPPING-THREADING MACHINES: Five sizes of Huller precision automatic units for mass production. Entirely automatic operation cycle; positive electrical controls, exact limitation of feed depth, wide speed range and high output. Maximum thread cut in steel ranges from $\frac{3}{16}$ to $1\frac{3}{16}$ in.; in brass, from $\frac{5}{16}$ to 1½ in. *Carl Hirschmann Co., New York, N. Y.*

HYDRAULIC SURFACE GRINDER: Jones & Shipman precision unit with 6 by 18-in. capacity. Adjustment of wheelhead is 0.0001-in.; fine adjustment for vertical wheelfeed is 0.0001-in. Wheelhead spindle runs in plain journal and thrust bearings; is hardened, ground and tapered at front end to receive grinding-wheel flange plates. Bearings are diamond bored; spindles are ground and superfinished to within 2 microinches, rms. Drive to spindle is from 1-hp, constant-speed motor. Table traverse arranged for either hydraulic or hand operation. *British Industries Corp., New York, N. Y.*

WELDING ATTACHMENT: Used with gas-shielded arc welders, Fillerweld permits control of automatic continuous flow of filler-metal by means of finger switch mounted on torch. Flow can start or stop without breaking arc. Gun is a manual water-cooled inert-arc holder with a control switch and gear assembly for pulling filler-metal from spool to arc. Accommodates tungsten wire from 0.040 to $\frac{1}{16}$-in. diameter and up to 7 in. long. Mechanical power unit consists of motor to provide power for drawing filler-

WHAT ABOUT STRESS RAISERS? *This book gives the answers..*



How to avoid the localized stresses which start failure is a basic problem of design. This 72 page booklet analyzes many good and bad features of design. It also deals with problems of steel selection and treatment from the viewpoint of the design engineer —instead of the metallurgist.

Write for "3 Keys to Satisfaction"—it is free.

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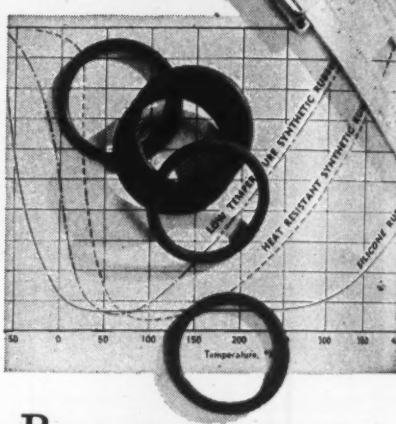
SILICONE "O" RINGS OFFER UNIQUE DESIGN POSSIBILITIES



Because of the inherent stability of silicone rubber, Arrowhead "O" rings molded of this remarkable new material provide a long-lasting seal under conditions far beyond the limits of ordinary rubbers. For example, they remain flexible at -130° F.; withstand indefinitely, exposure to temperatures of 500° F. and over. They offer excellent resistance to oxidation, to many oils, acids, alkalies and a variety of chemicals. The ideally inert characteristic of these seals is demonstrated by their astonishing resistance to aging, even at abnormally high temperatures. At normal temperatures they last *indefinitely.* For superior performance under severe conditions, consider silicone rubber. Arrowhead's *silicone specialists* will welcome your inquiry.

Write FOR ENGINEERING DATA

Free to Engineers—two valuable new publications on silicone rubber and "O" rings. Contain complete technical and descriptive data, including typical applications.

ARROWHEAD RUBBER CO.
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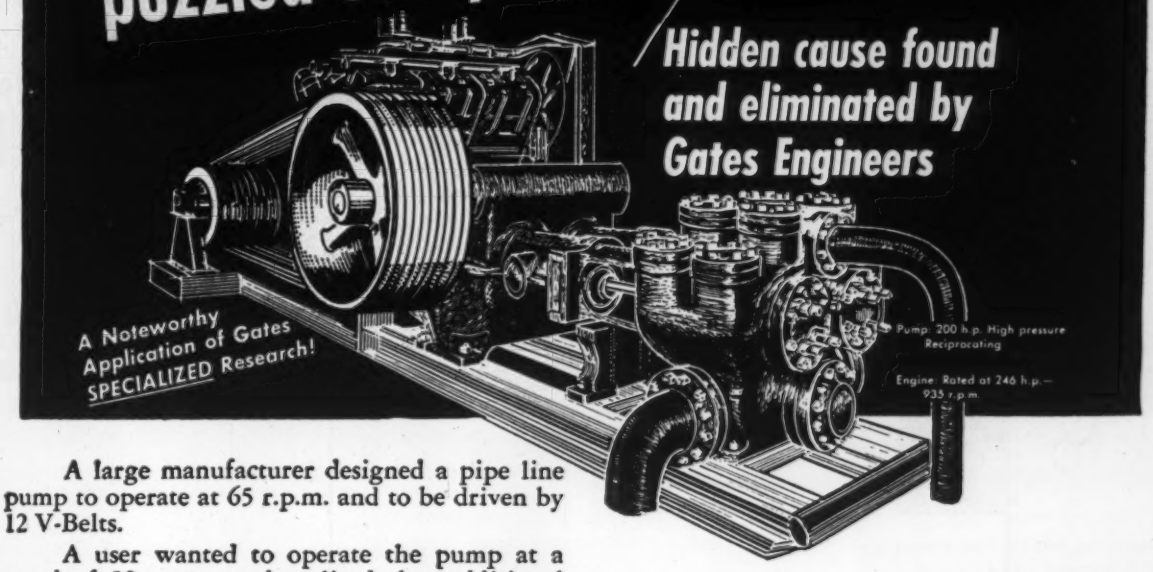
"O" RINGS ▼ SILICONES ▼ AIRTRON-DUCTS

Severe vibration on pump drive puzzled everyone . . .

Hidden cause found and eliminated by Gates Engineers


A Noteworthy Application of Gates SPECIALIZED Research!
Pump: 200 h.p. High pressure Reciprocating
Engine: Rated at 246 h.p.— 935 r.p.m.

A large manufacturer designed a pipe line pump to operate at 65 r.p.m. and to be driven by 12 V-Belts.

A user wanted to operate the pump at a speed of 90 r.p.m. and realized that additional horsepower would be required. Upon checking the V-Belt drive, it was found that the additional belts required would increase the face width of the sheave and therefore the moment arm of the bearing load. Any increase in bearing load combined with the increased speed was distinctly undesirable and therefore the user sought some means of reducing the overhung weight and width of the sheave.

Learning that a *special* V-Belt had a sufficiently higher horsepower rating to gain the greater pump speed with *only 9 belts,* he had the drive re-designed to use these belts.

When installed on the job, the belts vibrated severely. At a speed somewhat below the desired range, the belts would fly completely off the sheaves. Operation was so rough that it was almost impossible to run the pump at all.

Gates Engineers were called in for consultation. Their analysis indicated that the particular belts used formed a *too-compliant* link between the pump and the engine. This allowed tortional vibration to build up to excess. Therefore, belts of *less compliance* would have to be used.

Accordingly, Gates Engineers wrote specifications for belts having the necessary h.p. rating but with the exact *degree of compliance* that would avert the vibration. These special V-Belts were built by Gates—installed—and the drive operates smoothly under all loads and at all speeds within the range.

The excessive vibration is gone. The clutch operates smoothly at any speed. And 13 additional pumps have since been equipped with identical belts—all operating most satisfactorily.

Gates ability to analyze and correct obscure drive difficulties is no accident—for Gates operates the largest V-Belt Testing Laboratories in the world. And Laboratory findings are carefully checked by tests made under actual field conditions. Finally, the *results* of these exhaustive tests are immediately reduced to *usable data* for the design of V-Belt drives to *perform whatever task may be required.*

Phone for a Gates Field Engineer

Only under exceptional circumstances, of course, will you ever need belts of special construction. But, more often, some drive in your plant may not be operating quite as it should. Or you may have a particularly difficult drive to design. Again, you may want to be sure what size and construction of V-Belts will give the most efficient and the lowest cost service on a certain drive. In any case, you have only to phone a Gates Field Engineer, *always near you* in all industrial centers.

Just look in your phone book under "Gates Rubber." A Gates Field Engineer will come right to your plant and put at your service the full benefits of Gates V-Belt knowledge and experience *without the slightest obligation!*

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DENVER, U. S. A.

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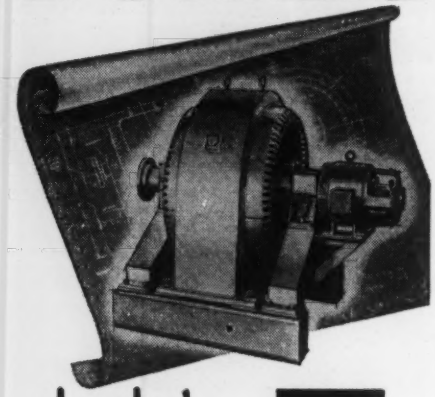

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metal, Thy-mo-trol motor controller and a spool. Unit is mounted on portable platform. Can be used with GE Type WP inert-arc welding transformer for welding aluminum, magnesium or beryllium copper; with Type WD-4150 or WD-4200 for stainless steel, copper, inconel, steel and other alloys. Either argon or helium can be used. *General Electric Co., Schenectady, N. Y.*

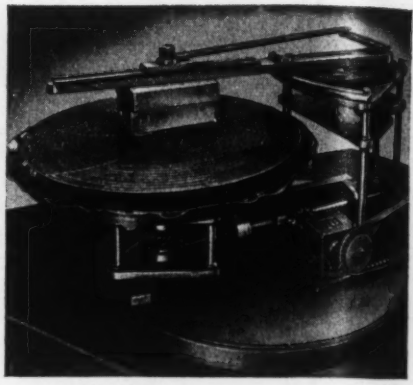
PUNCH SHAPER: Machines a blanking punch, hob or profiled part direct from the solid. Features simple set-up, high degree of accuracy and fine surface finish. Most punches can be completely finished on machine. Stroke of tool is adjustable from 1½ to 4¼ in. Upon completion of predetermined straight stroke, rocker arm operates in swivel motion, finishing off desired radius. *British Industries Corp., New York, N. Y.*

CUTTING MACHINE: Model D-3, $\frac{9}{32}$-in. capacity Pullmax has increased throat clearance for easy inserting and handling of bulky material. Equipped with longer cutting tools than previous model. Features quick locking devices on both circle and straight cutting attachments. Can also be used for beading, folding, slot cutting, nibbling and louvering by changing tools and attachments. *American Pullmax Co. Inc., Chicago, Ill.*

COLLAR EDGING ROLLS: Prepare a round sheet-metal pipe for joining with a flat sheet. Contour of rolls raises bead above surface of the pipe and crimps edge so that it is smaller than the pipe diameter. Crimped side of bead is flat to provide a good seat for the sheet, can be peened over easily to form a tight joint with the sheet. Rolls are made of hardened and polished alloy steel; are available for the No. 164 universal rotary machine, capacity 24-gage mild steel maximum, and for No. 172 electric combination machine, capacity 20-gage maximum. *Niagara Machine & Tool Works, Buffalo, N. Y.*

PORTABLE DRILL: Model 115 now equipped with ⅜-in. chuck and swivel ball side handle for two-handed operation. Recommended capacity, ⅜-in. in metal; ¾-in. in hard wood. Suitable to needs of vehicle body manufacturing and maintenance shops. *Cummins Portable Tools, Division of Cummins-Chicago Corp., Chicago, Ill.*

TUMBLING MACHINE: Has two 18 by 40 in. ID compartments. Offers increased capacity per area of floor spaced over previous equipment; permits grinding, deburring and



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This 3½ in. x 1¼ in. x 1¼ in. channel is used as a side frame by a maker of roll- and wheel-type conveyors. We make it from 10- or 11-gage SAE 1010 sheet steel, and furnish it to the manufacturer in straight lengths.

Side frames for mechanical conveyors are but one of a long list of practical uses for Bethlehem Cold-Formed Shapes. These versatile shapes are currently being used in such interesting applications as supports for telephone switchboards, parts for aircraft engine containers, side-plate sections for railway refrigerator cars, track sections for garage doors, and frames for window screens. And the list of additional uses is as varied as it is long.

Bethlehem Cold-Formed Shapes are regular or irregular shapes formed cold from strip, sheet or plate steel. They are uniform in thickness. Their surface is relatively free from scale. They have an ideal strength-to-weight ratio. We make them on presses, brakes or rolls in all gages from 5 to 24, and in virtually any length.

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finishing of metal parts in larg quantities in less time. Compar ments furnished with ½-in. pla unlined, or ¼-in. plate rubber-line doors have cam locks with manua ly released safety stops to provi pressure relief; magnetic start has reduced-voltage control to me plant electrical standards. Lim switch on safety guard cuts o current to stop barrel rotation whe guard is lifted. Motor is 5 hp, 22 440-v. *Grav-i-Flo Corp., Sturgi Mich.*

DRILLING-TAPPING MACHINE: Hor zontal unit provides high produc tion on large workpieces as we as on small production parts. Drive boring fixtures and drills, ream bores, counterbores, taps and spot faces at highest possible feeds an speeds. Box type column is heavil ribbed for rigidity and accuracy and 4-in. diameter spindle, wit 42-in. travel, slides in hardened steel sleeve mounted in precisio taper roller bearings. Spindle drive motor may be from 10 to 20 hp has 18 speed changes through slid ing gears. Traverse rate, 80 in. pe minute; overtravel prevented b limit switches. *Kaukauna Machine Corp., Kaukauna, Wis.*

CLEANING ATTACHMENT: Pipe and tube descaler and cleaner for Steer cut-off machines. Cleans rust, scale, paint and other deposits off pipes, posts and building columns. Sizes available for pipes up to 12 in. diameter. Feeds up to 20 ft of pipe per minute. *Continental Machine Co., Chicago, Ill.*

WORK FEEDER: Electrically-controlled air-powered rotary dial feeder with 22-in. diameter table top. Can be set to position 4, 6, 9, 12, 18 or 36 stations. Accurately loads up to 1000 lb. Powered by a specia 3⅝-in. bore air motor with built-in directional valve and speed controls Table top easily removed for mounting jigs and fixtures or over size tables. *The Bellows Co., Akron O.*

TAPPING MACHINE: Type ER com pound-table unit facilitates preci sion tapping of a number of same size holes on one or more level in bulky pieces where use of mul tiple heads is not practical. Work table moves on ball bearing race ways; has lateral travel of 20 in to either side, 13 in. forward and 11 in. backward. Push-button con trolled solenoid brake locks table i any transverse and longitudinal po sition. Specifications include: work table, 28 by 42 in.; 18 in. vertica travel with table top 56 in. from

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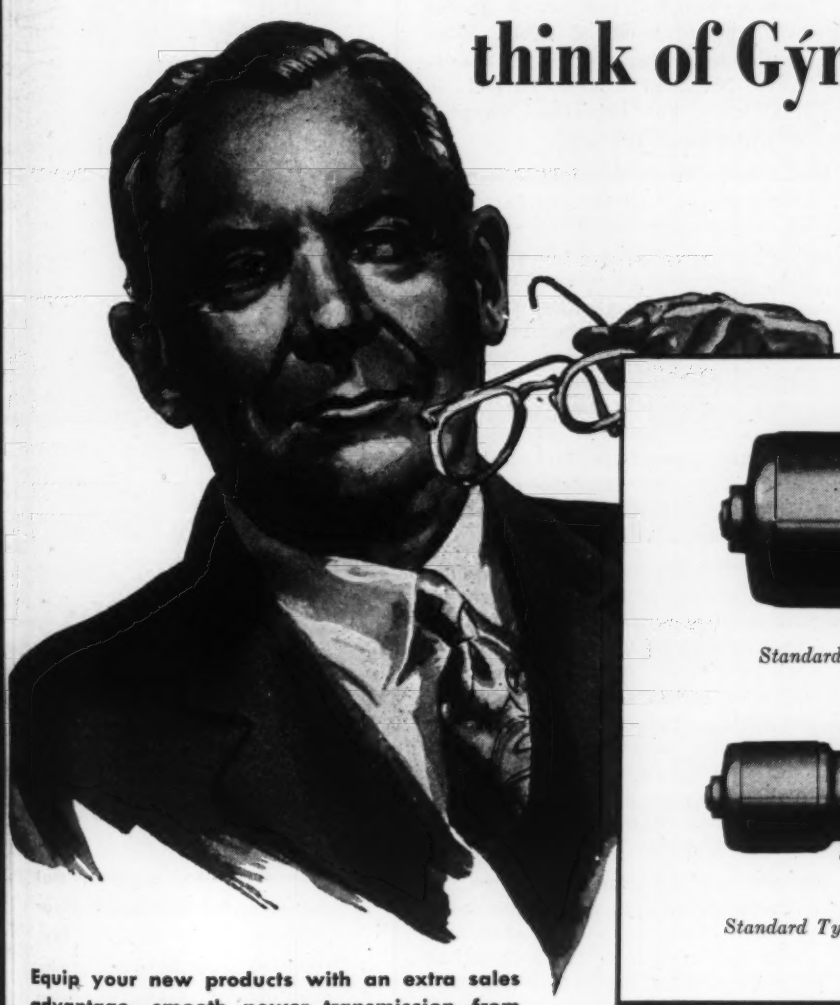

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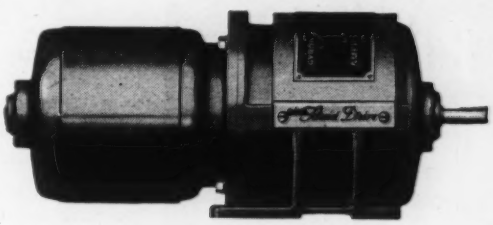
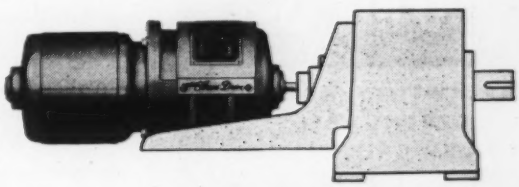


Standard Type TM Gýrol Fluid Drive Unit



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floor at maximum height; stroke adjustable up to 5-in.; base of machine, 64 by 38 in.; column, 25 by 20 in., is approximately 100 in. high with 26½ in. throat depth to permit handling of work pieces overhanging back of table. Sizes available for tapping ⅜ to 2¾-in. holes, National Coarse Thread, in mild steel. *The Cleveland Tapping Machine Co., Canton, O.*

DRILL JIGS: Single-post unit combines small size economy with accurate alignment. Esco Mijit B-6 is recommended for drilling small parts and for short and medium-size runs. Provides infinite number of locking positions; locking is positive and requires no pressure, releases with slight lift of handle. Accurate alignment between bushing plate and base maintained by means of hardened and ground post and alignment dowel. Full-size templates available. *Esco Engineering Corp., Detroit, Mich.*

PNEUMATIC RECIPROCATING SANDER: Straight-line action permits sanding up to right angles; does not cut abrasive patterns. Practically vibration free; efficient operating speed maintained with air pressure of 70 lb. Features new type abrasive holder, insuring ease in attaching even coarsest abrasive grits. Takes abrasive paper 3 2/3 by 9 in.; weighs less than 6 lb. *Detroit Surfacing Machine Co., Detroit, Mich.*

ELECTRIC DRILLS: For heavy-duty production drilling in metal and wood. Features include die-cast aluminum housing, trigger switch with safety locking device, sealed ball bearings, three-jaw geared chuck, chuck guard to protect worker's hands. Can be supplied in any standard voltage; operates on d-c or a-c, 60 cycles or less. Available in ¼, 5/16 and ⅜-in. chuck sizes and in D-shape and "drop" handle. *Stanley Electric Tools, New Britain, Conn.*

Materials Handling

FORK LIFT TRUCKS: Five models with capacities of 4000 lb at 24-in. load center, 3000 lb at 15-in. load center, 2000 lb at 24-in. load center, 4000 at 15-in. load center, and 4000 lb at 24-in. load center, with wheel bases of 48, 39, 40, 42 and 46 in., respectively. *Towmotor Corp., Cleveland, O.*

LOAD INVERTER ATTACHMENT: Provides method of inverting unit loads quickly, without taking them from their pallets. Consists of revolving head and set of top and bottom forks, with a plywood backstop and a side retaining board. Revolving

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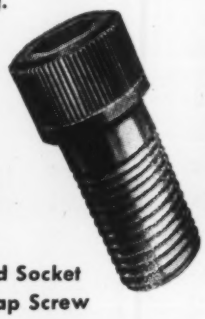

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1. To keep gas absorption during melting to a minimum, thus assuring sound, gas-free castings.
2. To effect complete deoxidation of the metal in the ladle before pouring.
3. To insure that each particular casting is poured at the precise metal temperature consistent with highest quality.
4. To insure that molding and core materials are so processed that the correct properties are obtained for good castings, and
5. To insure metal of uniform composition meeting the specification.

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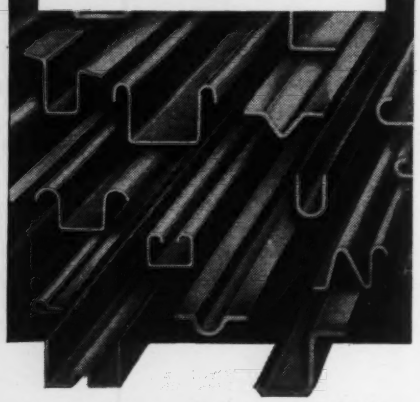

Of all the methods available for cold-shaping flat rolled metal, the cold-roll-forming machine offers the highest production per man hour and the lowest conversion cost. It is often a good investment even when operated only a few days per month.

Of still greater importance than conversion cost is often the saving of weight which may be effected by designing light, strong box, tubular and other special structurals to take the place of hot rolled angles, channels, tees, etc. Material savings up to 50% are frequently made.

In press forming of hat shapes to make stator rings for jet engines, up to 80% of the metal has to be cut away and discarded in order to obtain one ring. By cold-roll-forming the profile from strip, cutting to length, bending into rings and joining ends, this huge scrap loss is avoided. Here is another example of how a Yoder Cold-Roll-Forming production line may save scarce and expensive stainless steel, aluminum, brass and other metals. In such cases, the material savings alone are usually many times greater than the conversion cost, even for relatively small quantities.

Function, scope and economics as well as mechanics of cold-roll-forming are discussed in Yoder's 86-page illustrated book which will be sent on request. Recommendations and estimates for the asking.

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Cold-Roll FORMING MACHINES

ENGINEERING YODER MANUFACTURING

head turns load 180 degrees. Can be installed on any Baker 3000 or 4000-lb capacity fork truck. *Baker Industrial Truck Division, The Baker-Raulang Co., Cleveland, O.*

COUNTING MACHINE: Handles variety of parts with 100 per cent accuracy. Requires less than ten minutes to change over from one size or shape to another. Between 2000 and 3000 small screws or rivets or 3000 to 3500 small nuts can be handled per minute. Hopper at floor level meters items to be counted into buckets of elevator which empties them into feeder at top of machine. Two parallel rollers inclined at a 20-degree angle align parts and feed them in a single row onto counting chute, past electric eye, into vane housing and then into container. Machine can be set to fill any quantity into a package from one to 1000. *U. S. Engineering Co., Long Island City, N. Y.*

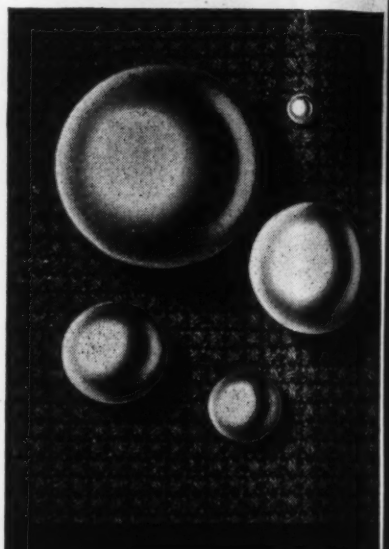
MOTOR-DRIVEN TROLLEY: Hydraulic coupling transmits power from motor to drive unit. Motor starts unloaded and comes up to 85 per cent of full speed before starting the load. Power requirements are low; acceleration is smooth and gradual. Fluid coupling available for Yale power driven trolleys from ⅛ to 12-ton capacity. *The Yale & Towne Manufacturing Co., Philadelphia Division, Philadelphia, Pa.*

MATERIALS HANDLING RACKS: Designed to facilitate transportation and storage of small assemblies and metal, rubber or plastic parts. Units hold up to 12 removable trays stacked in six rows 12 in. apart. Tray capacity, 70 lb each; total capacity of rack, 1500 lb. Tray size, 24 by 31 in. Overall height, approximately 4½ ft. All four swivel-caster type ball-bearing wheels lock to hold unit stationary. Rack folds flat for storage. *Coleman-Pettersen Corp., Cleveland, O.*

FORK TRUCKS: Designed for operation in and around highway motor trucks and freight cars. Capacities up to 2000 lb. Trucker series has automotive type controls; hydraulic brakes. Features short overall length; is 68 in. high with telescopic lift collapsed. Duplex models can elevate forks 54 in. before secondary channels rise to increase height. *The Yale & Towne Manufacturing Co., Philadelphia Division, Philadelphia, Pa.*

DEFLECTOR: Attaches to platform end of telescoping portable conveyor; automatically guides cartons off permanent belt conveyor and shunts them at 90 degrees onto portable telescopic conveyor into truck,

a metal ball PROBLEM?



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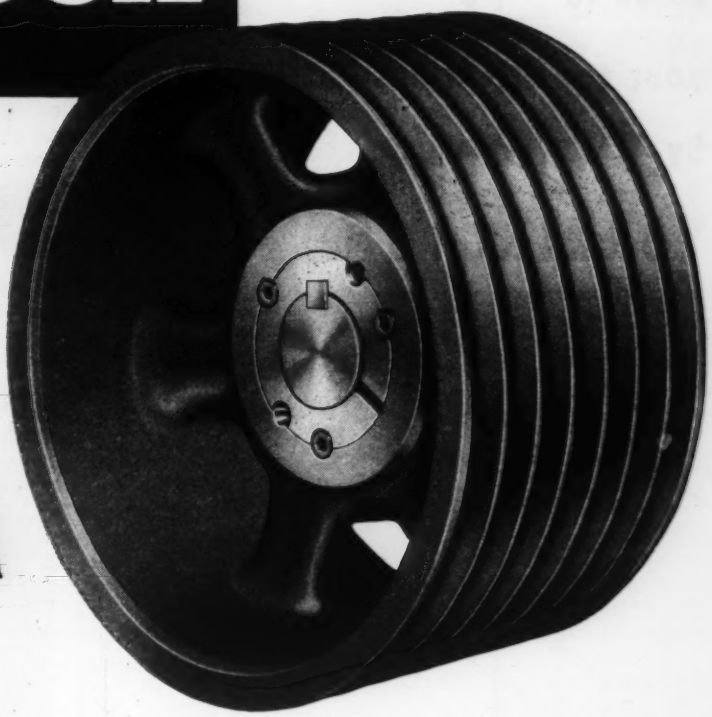

TAPER-LOCK bushing grips the shaft for the full length of the bushing — holds sheave with firmness of a shrunk-on fit. No wobble. Taper-Lock runs true!

No flange—no collar—no protruding parts. Flush machine-tool appearance.

Finest grade of close-grained semi-steel, cast in the Dodge foundry.

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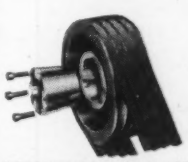
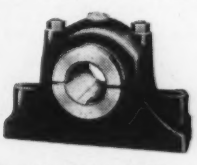
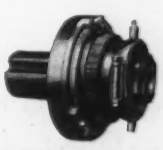


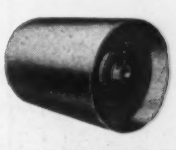
V-BELTS AND TAPER-LOCK SHEAVES



DODGE-TIMKEN PILLOW BLOCKS



ROLLING GRIP AND DIAMOND D CLUTCHES



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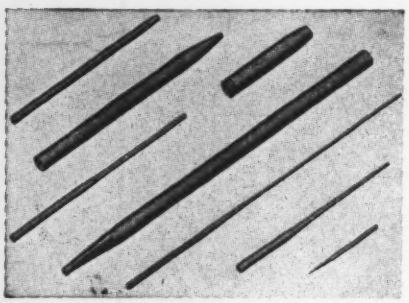

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TORRINGTON NEEDLE BEARINGS

trailer or box car. Both right and left-hand units available. Features include fully automatic operation to stacking point, quick, easy setup. *Wilkie Co., Philadelphia, Pa.*

STOCK CRADLE: Motor-driven, automatic coil unit with 3000 lb capacity. Takes stock with maximum OD of 48 in. and maximum width of 15 in. Additional widths available. Actuating arm operates on inside or outside of the slack loop. Hardened and ground rolls are mounted in each of the two individually controlled guide plates. Size: 25¼ in. wide, 45 in. long, 33 in. high. *Rowe Machinery & Manufacturing Co. Inc., Dallas, Tex.*

Packaging Machinery

CONVEYOR GLUER: Automatically strips or solid-glues paper of all weights up to three-ply index and from 6 by 6 in. to 28 by 36 in. sheets. Delivers sheets glue side up on endless belt conveyor. Forced drying equipment and suction conveyor for thin sheets available. Has variable speed control up to 3000 sheets per hour and can use any kind of glue. Overall dimensions: 5 by 16½ ft. Conveyor belt supplied to any length. *Potdevin Machine Co., Brooklyn, N. Y.*

Plant Equipment

AIR FILTER: Model B Condensifilter removes water, oil, sludge and other foreign materials from compressed air. Capacity, 30 cfm at 100 psi. Recommended for use in combustion and process control; in soaking pit, blast furnace and open-hearth control; in operation of boilers, pneumatic tools, paint-spray, sandblast and laboratory equipment; and in the operation of agitation equipment in food and chemical processing and in electroplating. Condensing unit is composed of a series of copper coils; filtering unit is made of five hexagonal chambers, providing over 4 sq ft of filtering area. Size: 15 in. high by 9 in. diameter. *Hankison Corp., Pittsburgh, Pa.*

DEMINERALIZER: Cation and strong-base anion exchangers are intimately mixed in single unit tank. Recommended for power plants, mirror plating, electronic and anode tubes and photographic finishing. Models available in flow rates ranging from a few to 5000 gallons per hour and up. *Penfield Manufacturing Co. Inc., Meriden, Conn.*

OIL AND GAS BURNERS: Include forced-air draft system which provides single blower fan for all air for combustion. Can be regulated to

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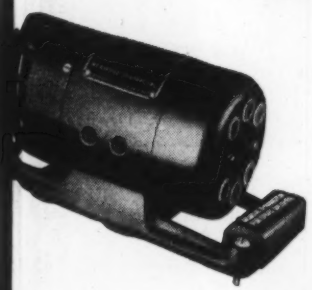

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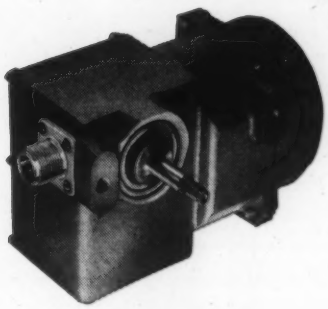
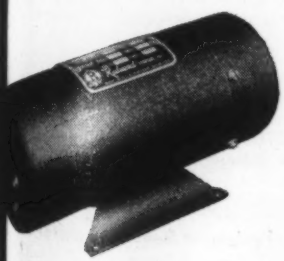


Windshield Wipers



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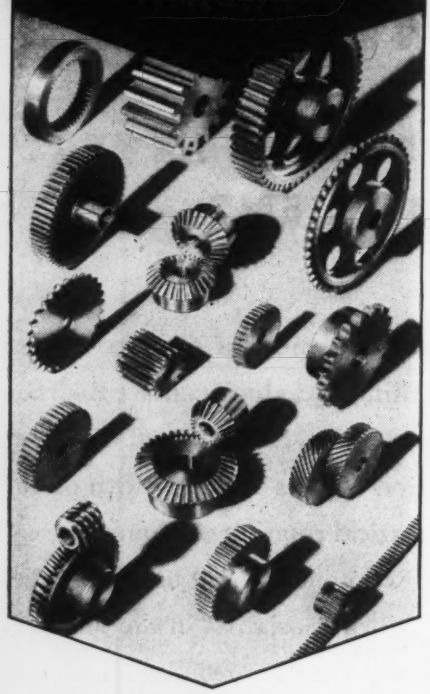

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burn proper amount of gas or oil for requirements of particular installation. Low-fire start accomplished with either gas or oil. Electronic controls prevent main gas valve from opening unless pilot flame is established. Changeover from gas to oil accomplished quickly. Models for burning gas range from 720,000 to 8,700,000 Btu maximum. *Cleaver-Brooks Co., Milwaukee, Wis.*

TURBINES: Multistage mechanical-drive units in ratings from 200 to 5000 hp. Designed to cover industrial applications, as well as for power-generation purposes. From two to ten stages may be used on multistage Types DP, DR and DRV. Type DRVX is designed for applications where process steam is desired at a definite, steady pressure. *General Electric Co., Schenectady, N. Y.*

OIL MIST PRECIPITATOR: Based upon the electrostatic precipitation principle of attraction. Oil mist from machining operations is charged as it passes through an electrostatic field and is then attracted to plates of opposite polarity from which it drains into a collecting pan for reuse. Constructed of heavy sheet metal. Adaptable for floor mounting or overhead ceiling suspension. *Trion Inc., McKees Rocks, Pa.*

Power Plant Equipment

DIESEL ELECTRIC PLANT: Model 3DSP-1E 3000-watt unit driven by four-cycle, single-cylinder diesel engine. Consumes approximately 0.155 gal of furnace oil per kw-hr at full rated load. Generates 115-v, 60-cycle, single-phase current. Other a-c models available in single-phase produce 230 and 115/230 v. *D. W. Onan & Sons Inc., Minneapolis, Minn.*

Processing Equipment

PORTABLE COOLANT UNIT: Furnishes ample cooling for eight or ten-spindle drill press. Pumps up to 12-ft head; capacity, 30 gpm. May be used on single-spindle drill press, lathe, broaching machine, cut-off machines or cutter grinders, or may be changed to feed three or four different machines simultaneously. Features ¼-hp, 110-v, 60-cycle motor; built-in switch; semifloating impeller; cast-aluminum pump housing. Size: 10 by 10 by 26 in.; holds 11 gal. Neoprene hose is ⅜-in. by 6 ft. *Shellback Mfg. Co., Hazel Park, Mich.*

PURIFIER: Receiver type unit for removing destructive entrainment from vapor lines. Applications in-

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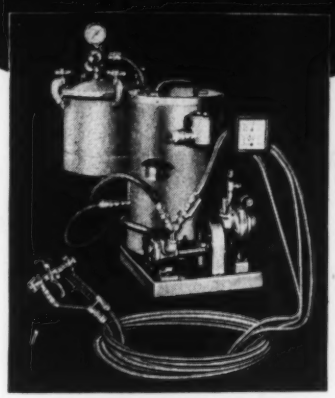

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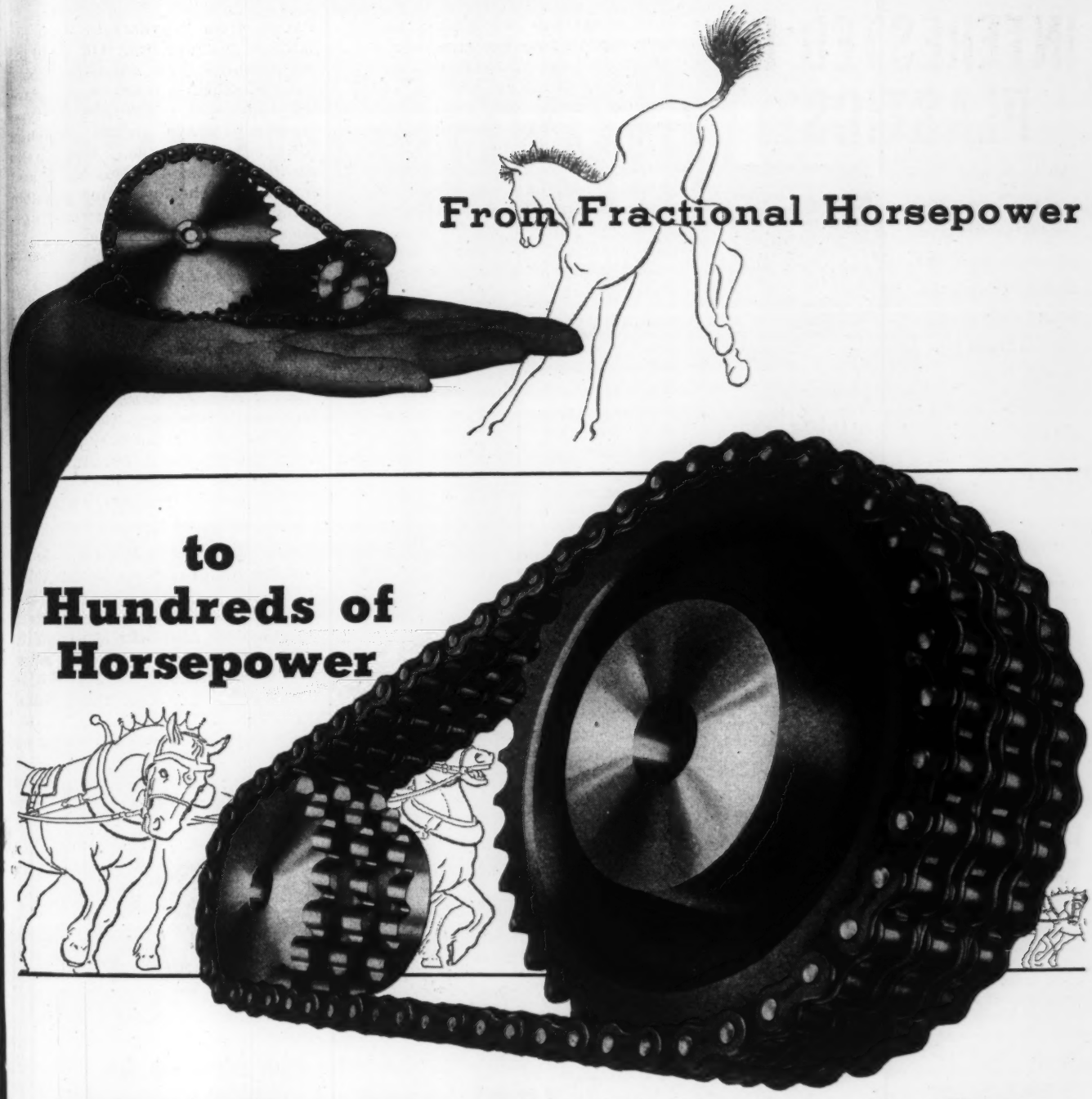

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